



**UTILIZATION OF DECISION ANALYSIS FOR SERVICE MEMBER
RETIREMENT OPTIONS**

GRADUATE RESEARCH PAPER

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AFIT-IOA-ENS-11-02

**DEPARTMENT OF THE AIR FORCE
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Wright-Patterson Air Force Base, Ohio

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GRADUATE RESEARCH PAPER

Presented to the Faculty

Department of Operations Research

Graduate School of Engineering and Management

Air Force Institute of Technology

Air University

Air Education and Training Command

In Partial Fulfillment of the Requirements for the
Degree of Master of Science in Operations Analysis

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June 2011

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Abstract

The Military Retirement Reform Act of 1986 and subsequent repeal in the FY2000 Military Defense Authorization Act resulted in a decision problem for all military members considering retirement. The proper choice between the accepting the \$30,000 Career Service Bonus and Redux retirement pay versus the traditional “High-3” retirement pay must be made by all members approaching 15 years of service. Unfortunately there is very little guidance available for this decision; what little there is can be misleading. The purpose of the model is to utilize decision analysis tools to help bring clarity to the decision problem and allow service members to make their decision based on their preference probabilities and resulting expected values of either decision. The model provides a comprehensive approach to the decision and results in a product that can be used by every service member approaching retirement.

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UTILIZATION OF DECISION ANALYSIS FOR SERVICE MEMBER RETIREMENT OPTIONS

I. Introduction

Background

The Military Retirement Reform Act of 1986 created an option for active duty members of the armed forces when determining their retirement pay. At the core of this decision is to determine whether or not a member should accept a \$30,000 Career Status Bonus at his/her 15th year of service in exchange for a reduced retirement percentage, or forgo the bonus and remain with the more traditional retirement plan. Both plans will be reviewed in Chapter II.

Problem Statement

Fundamentally the decision framework is to maximize total retirement pay for the service member. There are many retirement calculators made available on the Office of the Secretary of Defense website (OSD) ostensibly provided to help the service member this decision. While (hopefully) created with good intentions, these calculators are over-generalized and demand inputs from the member without guidance to the impact or the likelihood of the inputs occurring. The calculators can be frustrating in terms of comparison for this decision, and in some cases actually provide incorrect or inconsistent information.

Objectives

The purpose of this Graduate Research Project is to create a better model and tool for the service member to make his/her retirement pay decision. By applying advanced decision analysis techniques to the decision process, the model allows members to see the exact difference in Expected Value (EV) between the two decisions. Instead of inputs that force the user to project exact numbers on uncertain future events like rates of return and inflation, the model will allow users to place their personal preference probabilities for the likelihood of each occurrence. Ultimately the model will bring clarity to this very important financial decision that all retiring active duty service members must make.

II. Literature Review

Overview

The purpose of this section is to review the programs currently in place for service members' retirement options, the calculators available from the Office of the Secretary of Defense, and a review of the decision analysis tools that can be applied to provide a better model for the retirement decision

Part 1: History of Military Retirement Reform Act 1986

The Military Retirement Reform Act of 1986 was passed by Congress and introduced as Publication L. No. 99-348. (Hudson p.9) The immediate impact of this Act (also known as Redux) was substantial. Originally enacted as a means to increase overall retention beyond 20 years of service, it substantially reduced benefits for those separating at 20 years. Additionally, Redux raised the growth of retired pay for each year a member served beyond 20 years of service and reduced "the real value of the stream of retired pay in an inflationary environment." (Hudson). The basis of the original Redux plan is similar to today's plan with a few exceptions. Members of the Armed Forces who entered service after August 1, 1986 fell under the Redux plan. Instead of receiving 50% of their base pay if separating at 20 years (with an increase of 2.5% per year of additional service), the number dropped to 40% at 20 years with an additional 3.5% per year of additional service. Under either plan the max is topped out at 75% of base pay at 30 years of service. (Hudson) The annual Cost of Living Allowance (COLA) was also

lowered under Redux. Then (as now) the traditional “High 3” retirement increases retiree pay based on the Consumer Price Index (CPI). The Redux plan reduced this increase in pay by 1% per year. At age 62, retirees under the Redux would “catch-up” to the old system, and retired pay would be reset to the traditional retirement percentage (50% at 20 years) and fully adjusted for CPI growth. (Hudson) After age 62, COLA would be reduced to CPI-1% per year again.

Reason for input/authorization

The primary reason for the creation of the act was to reduce the total amount of spending for retirement. According to a report by the Federal Research Division of the Library of Congress, the Redux plan quieted criticism of the traditional 20-year system that it was too costly to the tax-payer. The report identifies the fact that “by the mid 1990s, Redux had reduced the DoD’s annual accrual charge by more than one-third compared with the pre-1980 system.” Another benefit touted by supporters of the Redux plan was that it provided a stronger incentive for service members to serve beyond the 20-year point. (Hudson) Furthermore, the study concluded that these initiatives under the Redux plan served to benefit retention in many skill areas.

Repeal/Re-introduction of High 3 plan

Although considered a success by supporters of the new plan because of the anticipated budget relief, Redux created numerous additional problems. It provided no incentive for military members to stay in unless they were willing to stay in for all 20 years. As Hudson points out, “Redux did not solve the basic force-management

difficulties associated with the 20-year system.” (Hudson) He continues that it did not change the basic retirement structure; that there was still reason for service members to stay in until reaching 20 years merely for the purpose of receiving the immediate annuity. This resulted in the continued problems of locking in mid-careerists and retained until 20 years many under-performing personnel. The Clinton administration in 1998 supported legislation to repeal the Redux retirement plan due to its negative impact on retention. The FY2000 National Defense Authorization Act repealed compulsory Redux and enabled service members to opt for the pre-Redux system or choose the Redux plan plus an immediate \$30,000 cash payment. (Hudson)

Part 2: DoD Financial Management Regulations

Volume 7A Chapter 66: Career Status Bonus/Redux Election Option

Members of the Armed Forces serving on active duty who became a member of the Uniformed Services on or after August 1, 1986, are eligible to participate in the CSB/Redux retirement option after completing 15 years of duty. Notification letters are sent after 14 years and 6 months of service. In order for an individual to make the CSB/Redux election, the member must submit their election form no later than the date the member attains 15 years of service. Payments can be made in a single lump sum of \$30,000, or annual installment groupings of two (\$15,000/year), three (\$10,000/year), four (\$7,500/year) or five (\$6,000/year). (DOD Financial Regulation)

The specifics of the plan are identified in title 10 of the United States Code section 1409. For those service members who select Redux and the \$30,000 Career Status Bonus (in any form), their retirement percentage is reduced from 2.5% per year for every year of service to 2.0% per year for every year of service from 0-20 years. So if a member selects Redux/CSB he or she will receive 40% of his/her base pay at the 20 year point. From years 20-30, the member's percentage of base pay increases to 3.5% per year to a maximum (with limited exceptions) of 75% of base pay at year 30. So if a member stays in for 30 years, he or she will retire with 75% of base pay, same as the traditional or High – 3 retirement option.

Another key distinction (and financial drawback for the service member) of the Redux plan is the Cost of Living Allowance (COLA) increase. Under the Redux plan, service members will receive 1% less of an increase than they would receive under the High – 3 plan. The COLA increase follows the Consumer Price Index (CPI), so if the CPI increases by 3% in a given year, then the COLA will increase by 3% under High – 3, but only by 2% for Redux. At age 62, those members who select Redux “catch-up” to the High -3 plan. This means that those under the Redux plan have their retirement pay recalculated as if they had retired under the High – 3 option. So a member who selected Redux and retired after 20 years of service with 40% of his base pay would see that number increase to 50% of his/her base pay and a COLA increase equal to CPI. In other words, at age 62 he would receive the exact same amount under the Redux plan as he would under the High 3 plan. This becomes the new base pay, but after age 62 the

service member under High 3 continues with COLA equal to CPI, while under Redux the service member increases at CPI – 1%.

Specifics of High 3 Plan

The High 3 plan is based on the legacy or traditional retirement option. Service members do not receive the \$30,000 CSB. The calculation for their retirement pay is based on 2.5% per year from years 0-30. So a service member retiring after 20 years of service will receive 50% of his/her base pay. A member who retires after 30 years would receive 75% of base pay. As mentioned previously, COLA increases according to CPI, so if CPI increases by 3% in a given year, then COLA would increase by 3% as well. Although it does not have the \$30,000 Career Status Bonus, the monthly/annual retirement pay is more under the High 3 plan than the Redux plan except for pay at age 62 and the other possible exception of the first year of retirement if a service member stays in for 30 years.

So the question is clear: what is the better option? What advice or guidance can leaders provide their airmen when it comes to this very important financial decision? The simple answer up until now has been the same: it depends. This answer is technically correct: it certainly does depend on a sequence of decisions still available to the service member such as retirement timeline and investment options as well as unknown variables including inflation and rate of return on investment. Typically members are pointed to the retirement calculators available on the OSD website. Unfortunately, the underlying assumptions on these calculators do not provide the fidelity a service member needs to make an appropriately informed decision. This necessitates the need for a model which

can accept stochastic inputs and a service member's preference probabilities into his decision problem. Utilizing decision analysis techniques the model developed in this research provides the service member the ability to more accurately predict the expected value of his/her retirement.

Part 3: OSD Calculators

The Office of the Secretary of Defense maintains four different retirement calculators on its website, including separate calculators for the both the High-3 plan and the Redux/CSB plan as well as a "retirement choice" calculator designed to help service members make the proper decision. Looking at each of these calculators and their underlying assumptions in greater detail shows some flaws in these calculators as the sole tool for this decision.

High 3 Calculator

The High 3 calculator is designed simply to show annual and cumulative retirement pay compensation. The required inputs for the service member include his or her career factors (year of retirement, years of service at retirement, and grade at retirement) as well as predicted economic factors for inflation, annual active duty pay raise, and tax rate. The default values are 3.5% inflation, 3.5% pay raise, and 28% tax rate, but can be changed. The range of values for inflation is 2%-6%, and the range of values for active duty pay raise is 2%-4%. Users therefore cannot "assume" the 1.4%

raise from 2010-2011 or the 0% COLA increase during the last two years (2009-2010 and 2010-2011). The inputs are seen below:

High-3 Retirement Calculator

① Career Factors

Please adjust each of the factors below to suit your situation. Click on the label for a definition of the term and, in some cases, additional information.

| | |
|---------------------------------------|------|
| <u>Year of Retirement</u> | 2017 |
| <u>Years of Service at Retirement</u> | 20 |
| <u>Grade at Retirement</u> | E-7 |

② Economic Factors

You may accept the default values below or adjust the values based upon your expectations about the economy.

| | |
|-------------------------------------|------|
| <u>Inflation Rate</u> | 3.5% |
| <u>Annual Active Duty Pay Raise</u> | 3.5% |
| <u>Tax Rate</u> | 28% |

Calculate

Figure 1: High 3 Calculator

After entering all information, the calculator returns charts with annual, cumulative, and before/after tax calculations, summarized in the following table:

Summary Results Table

The following table displays: 1) the before-tax monthly, annual, and cumulative retired pay and 2) the after-tax annual and cumulative retired pay for selected milestones in your retired career.

| Years Out | Year | Before Taxes | | | After Taxes | |
|-----------|------|--------------|------------|-------------|-------------|-------------|
| | | Monthly Pay | Annual Pay | Cumulative | Annual Pay | Cumulative |
| 1 | 2017 | \$2,448 | \$29,380 | \$29,380 | \$21,154 | \$21,154 |
| 10 | 2026 | \$3,337 | \$40,043 | \$344,673 | \$28,831 | \$248,165 |
| 20 | 2036 | \$4,707 | \$56,484 | \$830,869 | \$40,668 | \$598,226 |
| 30 | 2046 | \$6,640 | \$79,676 | \$1,516,697 | \$57,367 | \$1,092,022 |
| 40 | 2056 | \$9,366 | \$112,391 | \$2,484,124 | \$80,922 | \$1,788,569 |

These results were based on your choices and assumptions. The future will differ from these assumptions and actual results will differ correspondingly. Remember these comparisons are not guaranteed; they are merely estimates.

Figure 2: High 3 Results

The calculator takes the user inputs for active duty pay raise to calculate the initial pay at retirement:

RPO: Initial Retirement Pay

RRBP: Retirement Rank Base Pay

IR: % Inflation Rate (Annual)

ADPR: % Active Duty Pay Raise (Annual)

$$RPO = .5 (RRBP + (ADPR * \# \text{ years until retirement}))$$

This is a valid assumption although slightly flawed due to the previously mentioned constraints on user inputs. Then the user-defined inflation rate is used as an input for annual COLA increases according to the following calculation:

n = number of years of retirement

$$RP_n = (RP_{n-1} * IR) + RP_{n-1}$$

Again this is a valid assumption but the similar flaws still apply. In this calculator there is no basis for savings – it tells the user how much he/she will receive in retirement for 40 years after retirement.

Redux/CSB Calculator

The Redux/CSB calculator is similar to the High 3 calculator but it is specifically tailored to the service member who has already selected the CSB option. There are more

user inputs in this model, adding the current value of the CSB, the amount in TSP and taxable investments, and the rate of return on both sets of investments:

CSB/REDUX Retirement Calculator

① Retirement Expectations

The first step in determining your retirement pay flow is to establish your retirement expectations. Please consider your planned retirement year and grade and answer the following questions.

| | |
|--|------|
| In what year do you plan to retire? | 2017 |
| What will be your age at retirement? | 38 |
| How many years of service do you plan to have at retirement? | 20 |
| At what grade do you hope to retire? | E-7 |

② Current Value of CSB

What is the value of your \$30,000 CSB? Change the default values below to match your current account balances.

| | |
|-------------------------------|----------|
| Amount in Thrift Savings Plan | \$ 0 |
| Amount in Taxable Investment | \$ 30000 |

③ Economic Factors

Lastly, please consider what you expect to be the average economic conditions through the remainder of your career and the whole of your retirement. You may accept the default values below or adjust the values based upon your expectations about the economic conditions.

| | |
|------------------------------|------|
| Inflation Rate | 3.5% |
| Annual Active Duty Pay Raise | 3.5% |
| Tax Rate | 28% |
| Return on Investment (TSP) | 8% |
| Return on Investment (Other) | 8% |

Calculate

Figure 3: Redux Inputs

The restrictions on user inputs data remain the same as for the High 3 calculator. Additionally, the range of inputs for return on investment starts at a low of 5% and increases to 24%. The output from this calculator shows the monthly retirement pay based on user inputs (including the catch-up at age 62) as well as the accumulation of the savings from the bonus. The calculator assumes that the amount identified in either the TSP or taxable investments will be saved and compounded at an interest rate based on user input, and taxed as appropriate. The charts are also summarized in a final table:

Summary Results Table

The following table displays the annual and cumulative retired pay, the accumulated savings by saving the bonus, and the combination of retired pay and bonus accumulation. All values are after-tax, as appropriate.

| | Age | Annual Retirement Pay | Cumulative Retirement Pay | Bonus Accumulation | Total Retirement Pay + Bonus Accumulation |
|-----------------|-----|-----------------------|---------------------------|--------------------|---|
| Current | | \$0 | \$0 | \$30,000 | \$30,000 |
| Retirement Year | | | | | |
| 1 | 38 | \$13,512 | \$13,512 | \$31,727 | \$45,239 |
| 10 | 47 | \$16,873 | \$151,358 | \$52,520 | \$203,878 |
| 20 | 57 | \$21,600 | \$345,105 | \$91,948 | \$437,053 |
| 30 | 67 | \$43,632 | \$683,364 | \$160,975 | \$844,339 |
| 40 | 77 | \$55,857 | \$1,184,417 | \$281,821 | \$1,466,238 |

These results were based on your choices and assumptions. The future will differ from these assumptions and actual results will differ correspondingly. Remember these comparisons are not guaranteed; they are merely estimates.

Figure 4: Redux Results

The formulas used for the Redux Plan are similar to the High 3, except using the proper 2% / 3.5% format per year of service instead of 2.5%. The bonus accumulation is compounded annually based on rate of return and tax rate defined by the user. For everything identified in the TSP it is assumed to grow tax-free, so the accumulated bonus is based on the tax-free growth, not on the taxes paid when/if the money is withdrawn. The assumptions are valid but there are problems with this calculator as well. As previously discussed, the lowest percent rate of return is 5% -- certainly a lower rate of return than one would expect for stock investments, but probably a higher rate of return than one would expect at a later age when typically people are mostly invested in income producing bond products. There is no way to account for this investment strategy, so if a user chooses 10% as the rate of return, that 10% will be the calculated rate all the way through 40 years of retirement.

Retirement Choice Calculator

Another calculator on the OSD website is the Retirement Choice calculator, which is used to compare the alternative decisions. This is the most pertinent calculator to the decision maker and allows users to quantify and compare the value of their decision based on their inputs. This involves the most complex series of questions, asking users to determine their 15th year situation, including grade, combat zone participation, percentage of salary contributed to TSP:

High-3 vs. CSB/REDUX Retirement Comparison

① 15th Year Situation

In order to determine your estimated retirement pay flow, we must first establish your situation at 15 years of service. If you are not currently near your 15th year of service, please estimate.




| | |
|---|---|
| When will you reach your 15th year of service? | 2012  |
| What grade will you be at the beginning of you 15th year of service? | E-6  |
| Will you be in a combat zone at the beginning of your 15th year of service? | <input type="checkbox"/> Yes |
| What percentage of your salary do you plan to contribute to the TSP? | 0%  |

Figure 5: Retirement Choice Inputs Part 1

Additional inputs include the retirement expectations and economic factors similar to the previous two calculators. The factors include inflation rate, active duty pay raise, tax rate, and return on investment. Slightly different than the straight Redux calculator, the Choice calculator asks for the “Bonus Allocation” – how the user intends to distribute the bonus:

3 Bonus Allocation

How do you intend to distribute your \$30,000 Career Status Bonus? Change the default values below to match your intended allocation. Maximum amounts depend on your scenario, but we'll tell you if you've entered an invalid amount.

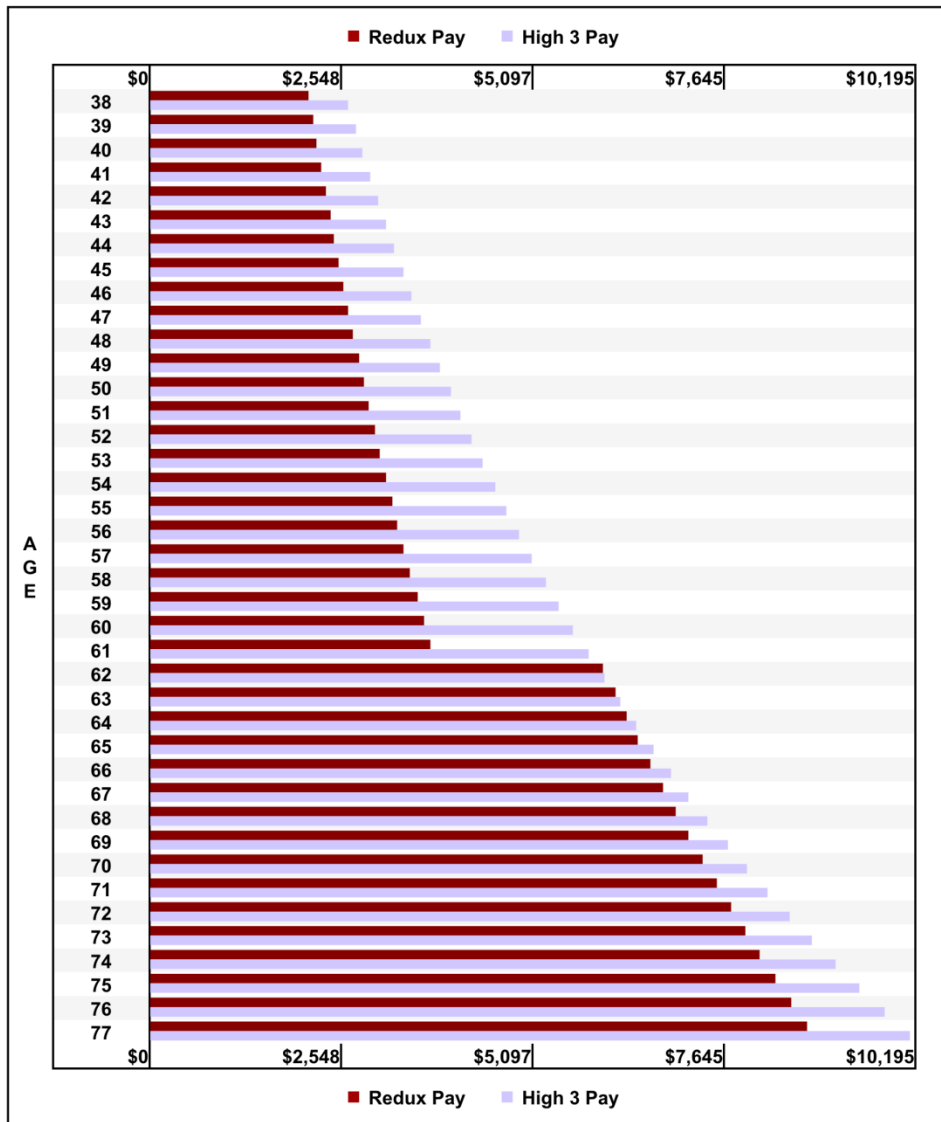
Based on your 15th year situation, your maximum allowable bonus allocation to the TSP is **\$0** to the nearest \$500

| | |
|---|---------------------------------------|
| Always use the maximum allowable TSP allocation | <input type="checkbox"/> Yes |
| Amount in Thrift Savings Plan | \$ <input type="text" value="0"/> |
| Amount in Taxable Investment | \$ <input type="text" value="30000"/> |
| Amount Spent on Purchases | \$ <input type="text" value="0"/> |
| Total (Automatically Calculated) | \$ 30000 |

Figure 6: Retirement Choice Input Part 2

The choice calculator asks for more inputs but the drawback remains the same – the limitations on the inflation rate and active duty pay raise and the necessity to make certain assumptions on unknown variables. The output from the calculator allows users to compare the difference between the two retirement plans.

The output of the choice calculator is similar to the other versions, but the choice displays the difference between the two plans in different formats. First, it shows a chart depicting the difference in monthly pay:



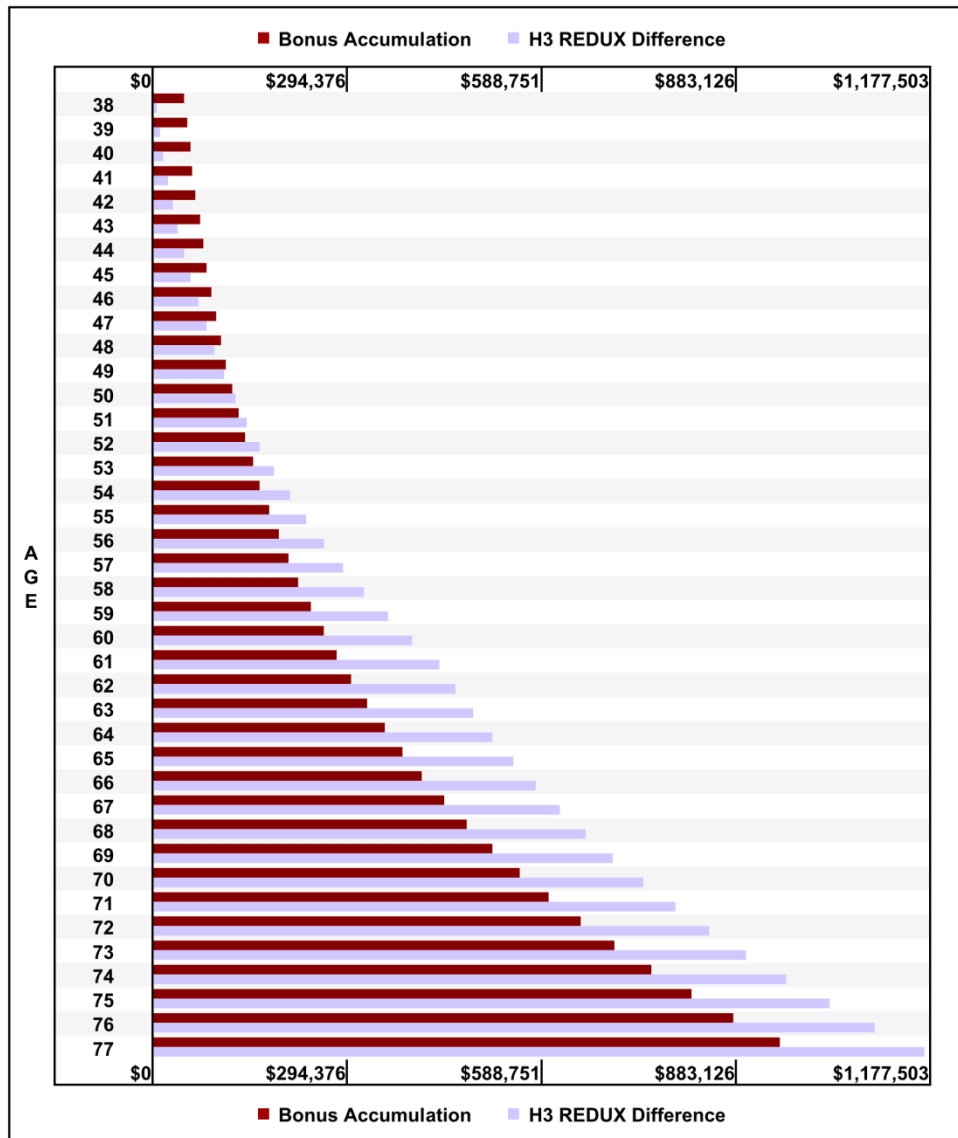
Assumptions:

| | | | |
|------------------------------------|------------------------------------|-------------------------------|------------------------------------|
| 15th year of service: 2011 | Age at 20 years of service: 38 | Thrift Savings Plan: \$30000 | Inflation Rate: 3.5% |
| Grade at 15th year of service: E-6 | Years of service at retirement: 20 | Other Taxable Investment: \$0 | Annual Active Duty Pay Raise: 3.5% |
| Combat Zone: No | Grade at retirement: E-8 | Spent On Purchases: \$0 | Tax Rate: 28% |
| TSP Contribution: 1% | | | ROI on TSP: 8% |
| | | | ROI on Taxable Investment: 8% |

Figure 7: Retirement Choice Output (Monthly Pay)

The chart only shows the difference in monthly pay – no calculations or assumptions for savings are shown. It accurately reflects the “catch-up” provision between the two plans

at age 62. The next chart displays the bonus provision against the difference in pay between the two plans:



Assumptions:

| | | | |
|------------------------------------|------------------------------------|-------------------------------|------------------------------------|
| 15th year of service: 2011 | Age at 20 years of service: 38 | Thrift Savings Plan: \$30000 | Inflation Rate: 3.5% |
| Grade at 15th year of service: E-6 | Years of service at retirement: 20 | Other Taxable Investment: \$0 | Annual Active Duty Pay Raise: 3.5% |
| Combat Zone: No | Grade at retirement: E-8 | Spent On Purchases: \$0 | Tax Rate: 28% |
| TSP Contribution: 0% | | | ROI on TSP: 8% |
| | | | ROI on Taxable Investment: 8% |

Figure 8: Retirement Choice Output (Cumulative)

The red “Bonus Accumulation” calculation is straight-forward. Based on user inputs, this shows the amount that the bonus will earn in tax or tax-deferred savings accounts. The H3/REDUX Difference is not quite as simple. It shows the amount that will be accumulated and earned based on saving the difference between the High 3 retirement option and the REDUX option. In the scenario from the charts, this difference is 50% of base pay for High 3 vs. 40% of base pay for REDUX (based on the input of 20-year retirement) and a 1% per year difference until age 62. The important factor to consider is that this option assumes that the service member will be aware of this difference and will always be able to invest that difference.

The final output of this calculator is a table which summarizes the results:

Summary Results Table

The following table displays: 1) The after-tax annual retired pay and 2) the accumulated savings by saving the Bonus under REDUX/Bonus for selected time periods.

| | | CSB/REDUX | | High-3 | |
|-----------------|-----|--------------------|--------------------|--------------------|------------------------------------|
| | Age | Annual Retired Pay | Bonus Accumulation | Annual Retired Pay | Saving High-3 and REDUX Difference |
| 15th YOS | 33 | \$0 | \$30,000 | \$0 | \$0 |
| Retirement Year | | | | | |
| 1 | 38 | \$18,412 | \$47,606 | \$23,023 | \$4,611 |
| 10 | 47 | \$22,991 | \$95,165 | \$31,378 | \$80,710 |
| 20 | 57 | \$29,428 | \$205,454 | \$44,262 | \$289,849 |
| 30 | 67 | \$59,469 | \$443,560 | \$62,436 | \$619,742 |
| 40 | 77 | \$76,127 | \$957,613 | \$88,073 | \$1,177,502 |

Figure 9: Retirement Choice Summary Table

This table highlights the difference between the two plans based on user inputs and the calculations previously discussed. Adding to the confusion is that the table actually shows the same money twice. First, it shows the difference in the annual retired pay between the two plans, and then it again shows what that extra pay would be worth if

invested. Although subtle, it is definitely an important factor that could be easily missed by the user.

Potential flaws with the calculators

While the calculators provide a tool for service members to analyze their different options, there are many potential pitfalls with the calculations, even if users completely understand the underlying assumptions. These include the limitations of the requested user inputs, problems with the underlying assumptions of the difference calculation, and in some cases completely inaccurate information.

For each calculator, the user is asked for a certain set of inputs. Because the Choice calculator requires the most inputs, it will be the one reviewed most thoroughly. First, service members must determine their 15th year situation. Assuming they are close to this situation, users should be able to determine with a high degree of certainty their grade and TSP contribution, but they might not know if they will or will not be in a combat zone.

The next series of questions, based on retirement expectations, is much more difficult for the user to determine because it requires the user to determine when they will retire and what grade they will retire in. This is an unknown for many service members and their decision has not been made. In order to compare the different options, they must run the calculator many times and then try to compare the differences of each plan. The decision analysis model simplifies this by producing an expected value based on

either decision or can produce an expected value based on the probabilities of the retirement timeline and projected rank.

The Bonus Allocation series of questions is fairly straight-forward, but has its own set of limitations. Service members should be reminded that they can distribute the \$30,000 bonus over 1 to 5 years, so unless users plan to maximize their TSP investment (currently \$16,500) each year, they should be able to invest all \$30,000 into the tax-deferred TSP. This option, however, is not available to the user in any of the calculators. They can distribute all \$30,000 into the TSP, but the calculator assumption would be that they do so in year 15 (instead of spreading to years 15, 16, and 17).

Finally, the Economic Factors section takes unknown future events and has the user make an assessment. These are all stochastic inputs, but the calculator assumes certainty with each factor, to include inflation rate, annual active duty pay raise, and rate of return on investment. For the first two factors, the user cannot even choose percentages equivalent to the most recent pay raises and inflation rate (COLA) increases. The model can produce results down to 0% for either of these options. Furthermore, a user has to choose a return on investment that somehow remains valid for 40 years after retirement. This is an unrealistic expectation, at least in the manner provided by the calculator. While an 8% return might sound like a realistic expectation, the fact is that as service members get closer to their final retirement from the workplace, their investments will in most cases change from a more aggressive long term growth outlook (stocks) to more conservative and near term income prospects (bonds). Almost all investment groups including Fidelity, USAA, and Vanguard have lifecycle plans to promote this type

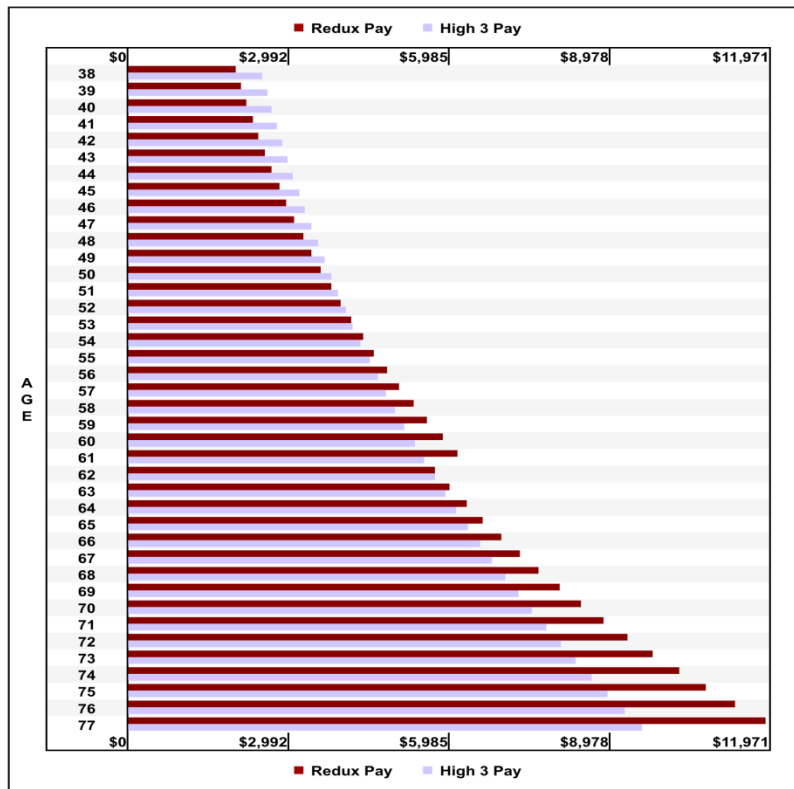
of investment strategy which matches risk tolerance to age. The Vanguard Group's Target Retirement Fund, for example, changes the mix of stocks and bonds as a client ages. When a client is anywhere up to 25 years from retirement, the mix is 90% stocks to 10% bonds. This begins to change at 25 years from retirement, and at the 15 year point the mix of assets is 75% stocks and 25% bonds, and by retirement (age 67) the allocation is 50% stocks, 50% bonds. (Vanguard, Inc., 2011) The calculator does not account for this, or provide the user with a means to determine what his or her actual rate of return will be. This is significant considering, "The consensus of investment science is that the long-term risk equity premium is probably about 4% to 5%." (Lawrence, 2011) The calculator does not even allow users to input 4%, even though that would be a much more realistic return approximation than the absurdly high return of 35% annual return.

Having this option likely promotes users to input unrealistically high rates of return into the calculators. Even if users wanted to estimate high rates of return for the initial period of investments, it is unrealistic to expect this to continue into later stages of retirement when investments will turn from growth producing stocks to income producing bonds as recommended by the financial institutions previously discussed. Unlike the calculator, the model allows users to estimate high, average, and low rates of return and quickly compare the difference in expected value for each option.

OSD Calculator Errors

In addition to some of the potential flaws and limitations of the calculators, there are also errors in certain inputs with the calculators. One such problem exists when users choose to enter one of the larger amounts for inflation rate, which in turn affects the

calculated CPI and COLA for each plan. The calculator actually produces results with an output showing the Redux plan paying more monthly wages than the High-3 plan after the “catch-up” at age 62. There is no reasonable explanation for this; it does not match how the calculators are supposed to work, nor does it follow the financial regulations that the calculations are based on. The following chart from the calculator is an example of this:



Assumptions:

| | | | |
|------------------------------------|------------------------------------|-------------------------------|------------------------------------|
| 15th year of service: 2012 | Age at 20 years of service: 38 | Thrift Savings Plan: \$30000 | Inflation Rate: 6.0% |
| Grade at 15th year of service: E-6 | Years of service at retirement: 20 | Other Taxable Investment: \$0 | Annual Active Duty Pay Raise: 3.5% |
| Combat Zone: No | Grade at retirement: E-7 | Spent On Purchases: \$0 | Tax Rate: 28% |
| TSP Contribution: 0% | | | ROI on TSP: 8% |
| | | | ROI on Taxable Investment: 8% |

Figure 10: Faulty Retirement Choice Output

The chart is a graphic depiction of how Redux pay will actually be higher than the High 3 pay after the 62 year catch-up. This is impossible, of course – according to the financial regulations previously discussed, Redux increases at a rate of CPI-1%, while the High 3 plan increases according to CPI. The following tables show the discrepancies – the first Microsoft Excel (2003), calculating the correct amounts of 5% vs. 6% COLA increases, and to the right the incorrect OSD calculations.

| 15th YOS | Age | Redux/CSB | | High 3 Savings | |
|----------|-----|----------------|-------------|----------------|------------------------------|
| | | Annual Ret Pay | Bonus Accum | Annual Ret Pay | Saving High 3 and Redux diff |
| | 33 | 0 | \$30,000 | 0 | 0 |
| 1 | 38 | \$17,427 | \$47,606 | \$21,791 | \$4,364 |
| 2 | 39 | \$18,298 | \$51,414 | \$23,098 | \$9,513.23 |
| 3 | 40 | \$19,213 | \$55,528 | \$24,484 | \$15,545.39 |
| 4 | 41 | \$20,174 | \$59,970 | \$25,953 | \$22,568.52 |
| 5 | 42 | \$21,183 | \$64,767 | \$27,511 | \$30,702.01 |
| 6 | 43 | \$22,242 | \$69,949 | \$29,161 | \$40,077.68 |
| 7 | 44 | \$23,354 | \$75,545 | \$30,911 | \$50,841.00 |
| 8 | 45 | \$24,522 | \$81,588 | \$32,766 | \$63,152.35 |
| 9 | 46 | \$25,748 | \$88,115 | \$34,732 | \$77,188.46 |
| 10 | 47 | \$27,035 | \$95,165 | \$36,815 | \$93,143.98 |
| 11 | 48 | \$28,387 | \$102,778 | \$39,024 | \$111,233.11 |
| 12 | 49 | \$29,806 | \$111,000 | \$41,366 | \$131,691.50 |
| 13 | 50 | \$31,296 | \$119,880 | \$43,848 | \$154,778.21 |
| 14 | 51 | \$32,861 | \$129,470 | \$46,479 | \$180,777.90 |
| 15 | 52 | \$34,504 | \$139,828 | \$49,267 | \$210,003.22 |
| 16 | 53 | \$36,229 | \$151,014 | \$52,223 | \$242,797.40 |
| 17 | 54 | \$38,041 | \$163,095 | \$55,357 | \$279,537.04 |
| 18 | 55 | \$39,943 | \$176,143 | \$58,678 | \$320,635.21 |
| 19 | 56 | \$41,940 | \$190,235 | \$62,199 | \$366,544.77 |
| 20 | 57 | \$44,037 | \$205,453 | \$65,931 | \$417,762.03 |
| 21 | 58 | \$46,239 | \$221,890 | \$69,887 | \$474,830.67 |
| 22 | 59 | \$48,551 | \$239,641 | \$74,080 | \$538,346.04 |
| 23 | 60 | \$50,979 | \$258,812 | \$78,525 | \$608,959.89 |
| 24 | 61 | \$53,527 | \$279,517 | \$83,236 | \$687,385.40 |
| 25 | 62 | \$56,200 | \$301,878 | \$88,230 | \$774,376.57 |
| 26 | 63 | \$59,002 | \$326,029 | \$93,524 | \$870,649.35 |
| 27 | 64 | \$61,937 | \$352,111 | \$99,136 | \$978,723.33 |
| 28 | 65 | \$65,010 | \$380,280 | \$105,084 | \$1,099,167.68 |
| 29 | 66 | \$68,227 | \$410,702 | \$111,389 | \$1,233,605.74 |
| 30 | 67 | \$71,594 | \$443,558 | \$118,072 | \$1,382,719.97 |
| 31 | 68 | \$75,117 | \$479,043 | \$125,156 | \$1,547,257.34 |
| 32 | 69 | \$78,802 | \$517,366 | \$132,666 | \$1,728,035.26 |
| 33 | 70 | \$82,655 | \$558,756 | \$140,626 | \$1,925,947.94 |
| 34 | 71 | \$86,684 | \$603,456 | \$149,063 | \$1,548,973.38 |
| 35 | 72 | \$90,895 | \$651,733 | \$158,007 | \$1,687,180.97 |
| 36 | 73 | \$95,285 | \$703,871 | \$167,488 | \$1,838,739.72 |
| 37 | 74 | \$158,448 | \$760,181 | \$177,537 | \$2,004,927.26 |
| 38 | 75 | \$166,371 | \$820,995 | \$188,189 | \$2,187,139.59 |
| 39 | 76 | \$174,689 | \$886,675 | \$199,480 | \$2,386,901.71 |
| 40 | 77 | \$183,424 | \$957,609 | \$211,449 | \$2,605,879.15 |

| 15th YOS | Age | CSB/REDUX | | High-3 | |
|-----------------|-----|--------------------|--------------------|--------------------|------------------------------------|
| | | Annual Retired Pay | Bonus Accumulation | Annual Retired Pay | Saving High-3 and REDUX Difference |
| | 33 | \$0 | \$30,000 | \$0 | \$0 |
| Retirement Year | | | | | |
| 1 | 38 | \$17,427 | \$47,606 | \$21,791 | \$4,364 |
| 2 | 39 | \$18,291 | \$51,414 | \$22,553 | \$8,877 |
| 3 | 40 | \$19,207 | \$55,527 | \$23,343 | \$13,524 |
| 4 | 41 | \$20,166 | \$59,970 | \$24,160 | \$18,297 |
| 5 | 42 | \$21,177 | \$64,767 | \$25,005 | \$23,179 |
| 6 | 43 | \$22,239 | \$69,949 | \$25,881 | \$28,155 |
| 7 | 44 | \$23,345 | \$75,545 | \$26,786 | \$33,217 |
| 8 | 45 | \$24,520 | \$81,588 | \$27,724 | \$38,333 |
| 9 | 46 | \$25,747 | \$88,115 | \$28,694 | \$43,487 |
| 10 | 47 | \$27,035 | \$95,165 | \$29,699 | \$48,656 |
| 11 | 48 | \$28,382 | \$102,778 | \$30,738 | \$53,814 |
| 12 | 49 | \$29,799 | \$111,000 | \$31,814 | \$58,928 |
| 13 | 50 | \$31,294 | \$119,880 | \$32,927 | \$63,955 |
| 14 | 51 | \$32,858 | \$129,471 | \$34,080 | \$68,860 |
| 15 | 52 | \$34,500 | \$139,828 | \$35,273 | \$73,599 |
| 16 | 53 | \$36,228 | \$151,015 | \$36,507 | \$78,117 |
| 17 | 54 | \$38,033 | \$163,096 | \$37,785 | \$82,368 |
| 18 | 55 | \$39,943 | \$176,143 | \$39,108 | \$86,277 |
| 19 | 56 | \$41,939 | \$190,235 | \$40,476 | \$89,783 |
| 20 | 57 | \$44,029 | \$205,454 | \$41,893 | \$92,818 |
| 21 | 58 | \$46,233 | \$221,890 | \$43,359 | \$95,290 |
| 22 | 59 | \$48,548 | \$239,641 | \$44,877 | \$97,107 |
| 23 | 60 | \$50,976 | \$258,813 | \$46,448 | \$98,172 |
| 24 | 61 | \$53,525 | \$279,518 | \$48,073 | \$98,374 |
| 25 | 62 | \$56,200 | \$301,879 | \$49,756 | \$104,047 |
| 26 | 63 | \$59,002 | \$326,030 | \$51,497 | \$109,308 |
| 27 | 64 | \$61,937 | \$352,112 | \$53,300 | \$114,057 |
| 28 | 65 | \$65,010 | \$380,281 | \$55,165 | \$118,206 |
| 29 | 66 | \$68,227 | \$410,704 | \$57,096 | \$121,647 |
| 30 | 67 | \$71,594 | \$443,560 | \$59,094 | \$124,261 |
| 31 | 68 | \$75,117 | \$479,045 | \$61,163 | \$125,915 |
| 32 | 69 | \$78,802 | \$517,368 | \$63,303 | \$126,469 |
| 33 | 70 | \$82,655 | \$558,758 | \$65,519 | \$125,772 |
| 34 | 71 | \$86,684 | \$603,458 | \$67,812 | \$123,055 |
| 35 | 72 | \$90,895 | \$651,735 | \$70,186 | \$119,928 |
| 36 | 73 | \$95,285 | \$703,874 | \$72,642 | \$114,391 |
| 37 | 74 | \$99,958 | \$760,184 | \$75,185 | \$106,827 |
| 38 | 75 | \$93,804 | \$820,999 | \$77,816 | \$96,991 |
| 39 | 76 | \$98,496 | \$886,679 | \$80,540 | \$84,621 |
| 40 | 77 | \$103,421 | \$957,613 | \$83,359 | \$69,433 |

Figure 11: OSD Calculator Errors

Comparing the two tables, the discrepancies are clear. The calculator accurately shows the Redux COLA increase at 5% each year until age 62. It inaccurately (underestimates) the 6% increase for the High 3 calculator. Inexplicably, by age 54 in this scenario (16 years after retirement) the Redux pay actually passes the High 3 pay. In fact, the age 62 “catch-up” actually reduces Redux pay to the incorrectly calculated levels. As a result, a service member who expected 6% annual COLA increases (however unrealistic) would not be correctly comparing the difference in pay. The excel chart has the correct figures for this calculation. The added problem is that the calculator then produces outputs which suggest the difference between saving the \$30,000 bonus vs. saving the difference in pay between the two plans is extremely inaccurate. As a cumulative sum, that difference should always increase, never decrease. But it actually decreases because of the improper calculations of the High 3 pay. So a service member would conclude that it is worth close to a \$1 million to decide in favor of the Redux plan, when this is simply not the case. In fact, using the given assumptions and saving the difference between the correct pay and compounding the interest at 8% annually (again, unrealistic), the correct total amount is \$2.85 million after 40 years of retirement – versus the calculator amount of just \$.07 million! A better model is therefore necessary for service members to better frame their decision situation and make a better prediction of their outcomes based on those decisions.

Part 4: Decision Analysis Tools

Ronald Howard, Stanford professor and one of the first to use the term, explains that Decision Analysis “specifies the alternatives, information, and preferences of the decision maker and then finds the logically implied decision.” (Howard, 2009) Decision Analysis techniques are specifically designed to solve the problem associated with the decision and set of alternatives and unknowns surrounding it.

In order to properly create a decision model, there are three fundamental steps. The first is to identify and structure the values and the objectives. The next step is to structure them into a logical framework, and the third step is to refine and identify the precise definition of all elements of the model. (Clemen, 2001)

In order to perform the first step, it is important for the analyst to properly structure the values and identify the objectives. Understanding the objectives is key to this step. There can be a single overarching objective or several objectives, and different models can be created and adjusted for either purpose. Examples of objectives can be business/finance related maximizing profit, minimizing costs, or optimizing efficiencies. In the case of multiple objectives, there is typically an overarching fundamental objective. In the relevant model to this decision context, the objective is fairly clear: to maximize the amount of money earned from a service member’s retirement plan. The values and different decisions must also be identified in a form which relates back to the objective. These values and decisions specific to the given model will be discussed further in Section III.

Once the objectives have been identified, it is then the job of the analyst to structure the decision in a manner that is meaningful to the decision maker or

stakeholders. There are several mechanisms to structure the model and different methodologies behind each. Influence diagrams can be useful to help structure the problem for future analytical use and also to give a general sense of the problem. Howard states that the influence diagram “is at once both a formal description of the problem that can be treated by computers and a representation easily understood by people in all walks of life and technical proficiency. It thus forms a bridge between qualitative description and quantitative specification.” (Howard, 2005) Influence diagrams can show probabilistic independence and also suggest probabilistic dependence. To clarify, if two entities x and y are probabilistically independent given the state of information S , then

$$P\{x,y|S\} = P\{x|S\}P\{y|S\} \text{ and } P\{x|y,S\} = P\{x|S\}$$

(Howard)

From influence diagrams (or independent of them) the analyst can build probability or decision trees. The trees are a succession of nodes which represent probabilities or decisions with branches from each of these nodes. Each branch can then be represented by the value of the uncertainty or decision. In the following decision tree,

the primary decision is represented by the square around the number 1, with another

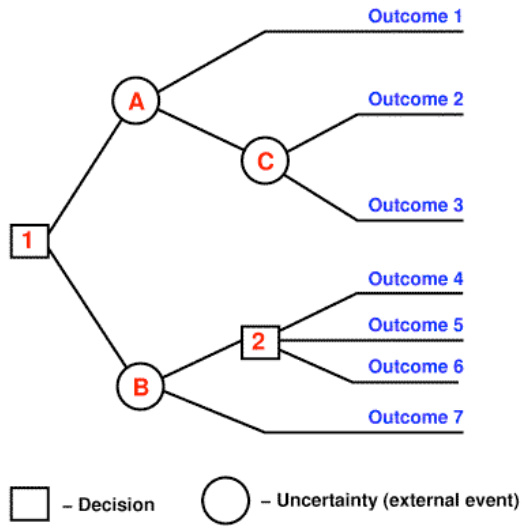


Figure 12: Decision Tree Example

decision around the number 2. The uncertainty nodes are represented by the circles around the letters. Each possible outcome would then have a different expected value associated with it. The decision tree is a valuable tool because it displays more details that might be missed in the influence diagram. In the decision tree, the branches coming from each decision represent the decisions available, while the branches coming from the uncertainty nodes represent the possible outcomes of that particular uncertainty. The consequences (outcomes) are displayed at the end of the final set of branches. (Clemen)

The structure of the decision is a very important part of the model, and several guidelines must be followed. First, the analyst must ensure that the options from each decision node are structured in such a way that the decision maker can only choose one option. Second, the chance nodes of the tree must have a collection of branches that are both mutually exclusive and collectively exhaustive. Mutually exclusive means that only

one of the outcomes happens and collectively exhaustive means that all of the possible outcomes are covered by the branches from that particular node. (Clemen) The decision tree must also represent all of the different possibilities that the decision maker will face through the captured time period, including all sequential chances and decisions that must be made. Finally, the decision tree should, when possible, follow the chronological sequence of events. (Clemen)

The utility of the decision tree and what makes it a powerful tool to solve even the most complex decisions is the power to clarify the objectives for the decision maker. By comparing each of the following outcomes combined with the probabilities along the way, the analyst can provide the decision maker with the Expected Value (EV), of that decision. (Clemen) This is done by “rolling back” or “folding back” the decision tree, starting with the outcomes and calculating the values associated with each chance node or choosing the highest values for each decision node. By working back through the tree, the decision maker can see the Expected Value associated with each decision and choose the highest Expected Value. For the given problem, because the objective is to maximize total retirement dollars, the Expected Value will be a straight monetary decision. When there are multiple objectives and decisions that involve more than money, different measures of objectives can be utilized with the same EV concept. These, however, are beyond the scope of the given problem.

There are many ways to apply decision trees to any given decision problem. Instead of the trial and error method of the OSD calculators, a decision tree model can be constructed to utilize a service member’s preference probabilities for uncertain outcomes

and help clarify his or her decision. Many advanced software programs can help with the modeling problem – the chosen software for this model is Palisade’s Precision Tree, which does the work of the computations for each possible decision and uncertainty and has the power to quickly calculate the EV of each decision given different user inputs. The specifics of the model and Precision Tree interface will be discussed in the next chapter. Although Precision Tree is used in order to interface with the spreadsheet, the model could also be designed as a stand-alone product; this is beyond the scope of this research.

III. Methodology

Overview

The purpose of this chapter is to outline the methodology used for the model development portion of the project. The first section will explore the different inputs for the model and the rationale behind each input. The next section will explain the structure of the model, starting with the framework and then explaining the more detailed creation of the decision. Finally, the calculations behind each of the decision tree components will be discussed.

Part 1: Model

The inputs for the model are similar to the OSD calculators but there are some key differences. The key to the model is a direct comparison of Expected Value between the two alternatives of the primary decision at hand, which is whether to take the Redux \$30K bonus or the traditional High 3 retirement. The question for the decision maker then becomes a question of their preference probabilities for the next series of unknown future events. The unknowns are: retirement year (20 to 30 years), retirement rank, annual inflation, rate of return on investment, taxed vs. tax-free savings, and the savings decision (i.e., whether or not an individual will save the \$30K bonus or save the difference between the two plans if taking the High 3 plan). For most service members, these inputs are all stochastic. Some users might already have decided they are going to retire immediately after 20 years of service and might also know with a high level of certainty what their rank will be at that time. The model can account for any of these

“knowns” by applying a 100% probability to the input. The other certainty that users will have is their age – the one user-defined input that will not have a stochastic measure.

Framework

Now that we have identified the objective and values for the problem, we are ready to look at the overall framework. The framework is a useful reference prior to the building the decision tree or the hierarchy because it helps to formulate the problem and identify any weaknesses or missing characteristics. As a tool for the decision maker it can help clarify what the analyst is building with the model. For this problem, the framework identifies the tasks associated with the model and the associated values and objectives:

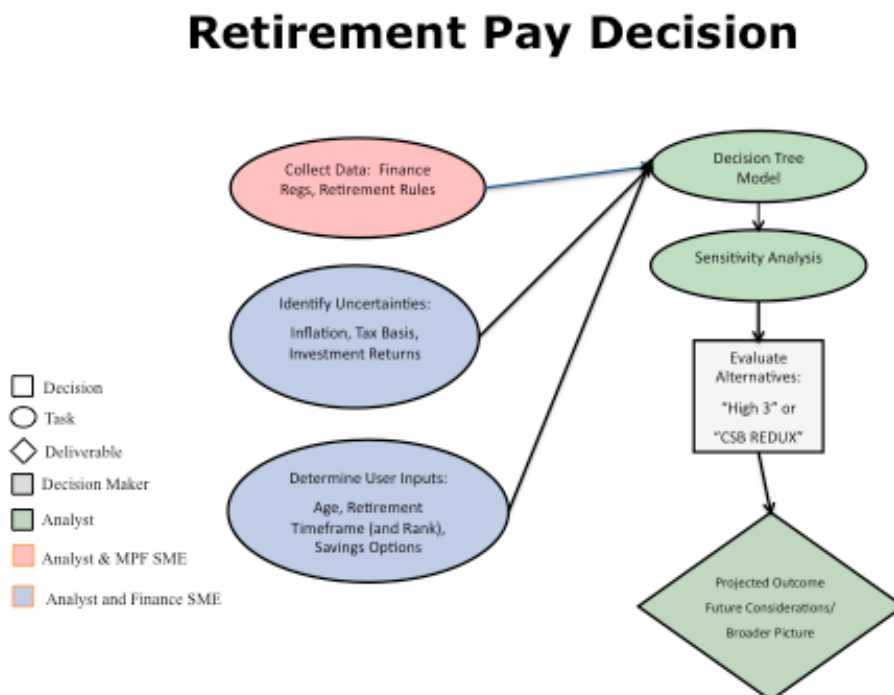


Figure 13: Model Framework

The framework establishes the relationship between tasks and also helps to identify the uncertainties involved in the decision. It serves as the basis for the next step, the hierarchy and decision tree model.

Hierarchy/Decision Tree Model

The model itself is a decision tree based on the objectives, decisions, and uncertainties previously discussed. The following is a depiction of the overall hierarchy of the model:

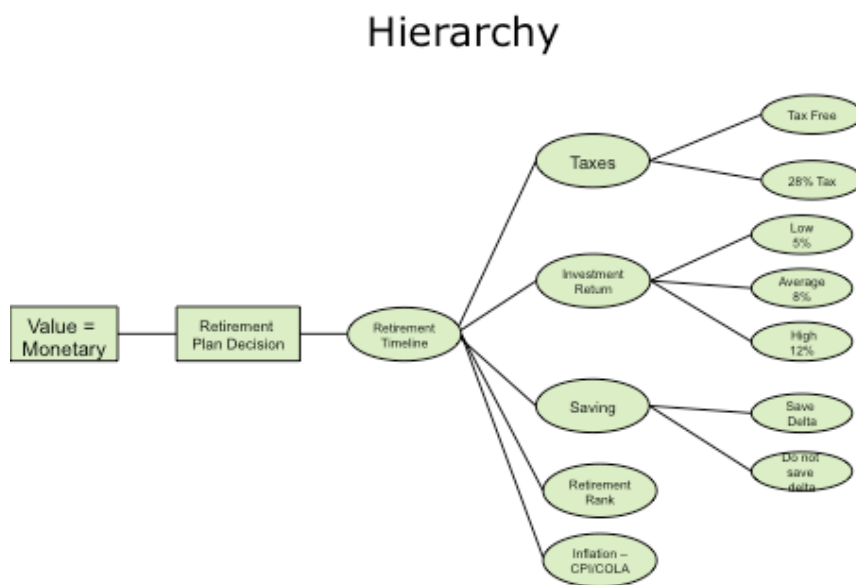


Figure 14: Model Hierarchy

The decision tree is much more detailed and specific. The tree model is excel-based using Precision Tree. It begins with the initial decision – in this model it is the only decision to be made – every other node is modeled as an uncertainty. However, if

the user has already decided that he/she is planning to retire at 20 years of service, then they can weigh the probability of that particular uncertainty at 100%. The beginning of the decision tree looks like this:

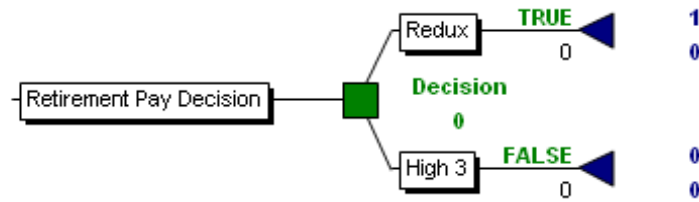


Figure 15: Model Decision Node

There is no user input for the correct decision. In fact, that is the point of the decision tree. With any given set of inputs, there will be 168 different possible outputs – the inputs and preference probabilities of the user will determine which of these outputs outweigh others, and based on those preference probabilities an expected value for both decisions will be the output of the model. The higher expected value would be the proper decision for the user. The next several uncertainties are the same for either branch of the tree. In the tree order, they are the expected number of years of service, high versus low rank, the expected annual active duty pay raise, and the expected rate of inflation. These uncertainties exist for both the Redux and the High 3 decision. It should be noted the model does not allow the high rank/20 year service combination. The node from 20 years goes immediately to 100% probability of the lower rank. The following section of the tree shows just the High 3, 25 year node and then all succeeding nodes until the payouts for that particular section of the tree. The High 3, 30 year looks exactly the same, while

the 20 year only calculates the lower rank outcomes. The Redux looks the same as the High 3 to this point.

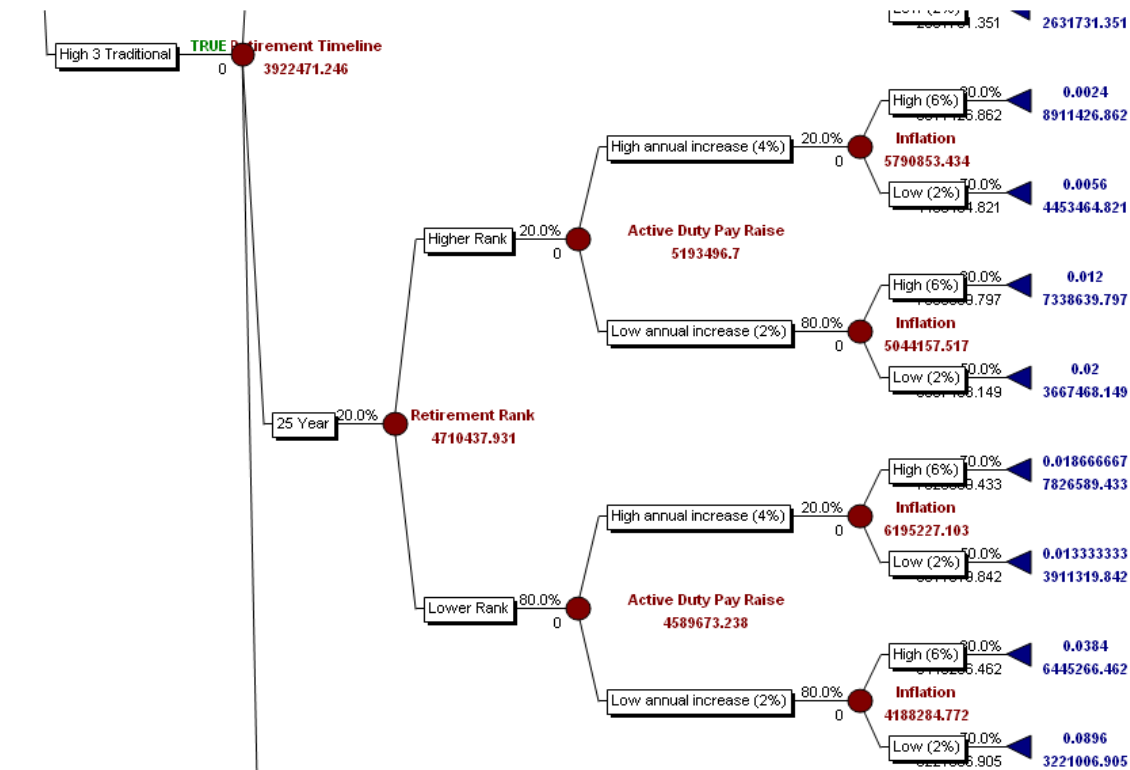


Figure 16: Decision Tree High 3 Example

The user chooses the probability of retirement at 20, 25, or 30 years, and then chooses the probability of attaining a higher rank than the base 20 year rank. In other words, if an officer expects to be an O-5 at 20 years, he/she might believe with some probability they will achieve the rank of O-6 at the 25 or 30 year retirement. The inputs of years of service and expected low rank set the basis for the initial pay. Using the 2011 pay scale, the 20 year base pay is based on the 16+ years of service, the 25 years is based on 22+ years of service, and 30 years is based on 26+ years of service. This is slightly

conservative – the true amount according to the finance regulations previously discussed will be the average of the final 3 years' pay. However, the difference is negligible and the importance of the model is not the final amount but a consistent basis of comparison.

The next set of user inputs is the probabilities for the annual pay raise and the inflation rates. The OSD calculators allow users to choose between 2% - 6% annual pay raise. The likelihood of 6% annual pay raise is so remote however, that this model limits the max pay raise to 4%. Users choose a likelihood of the higher (4%) pay raise, and the 2% likelihood is calculated based on that preference. The pay raise is the basis for the increase in base pay from 2011 until the service member retires at 20, 25, or 30 years of service. Hopefully service members will realize that the most recent pay raise was actually less than 2%, and the raise in 2012 does not look like it will be much greater. The inflation rate calculation is similar – users choose a preference probability for high (6% annual) versus low (2%). This forms the basis for the annual increase in pay after a service member retires – it will increase at the inflation rate (CPI) for members who elect the High 3 option, and increase at CPI-1% for those who elect the Redux.

The Redux (upper) portion of the decision tree does not end with the inflation rate uncertainty node like the High 3 (lower) portion in the previous table. Instead, the tree continues through two more uncertainties – first the probability of tax-free investment/savings of the \$30,000 Career Service Bonus, and next the rate of return on investment of the CSB. For the taxes, users can choose a probability of tax-free versus 28% tax on the bonus. It should be pointed out to service members that the CSB can be taken in installments, thus if they are not currently investing in or maxing out their TSP,

they could actually have the \$30K tax-free if taken in the two or three year payments. Another possibility for tax-free investment is if they are going to be deployed to a combat zone. The model assumption is that the service member does take the lump sum of \$30K during their 15th year of service.

The uncertainty node for return on investment has three different alternatives – conservative, moderate, or optimistic. All three options are based on the idea that users will earn a higher average rate of return earlier in their lives because they will be invested in growth producing stocks, and a lower rate of return later in their lives as their investment risk tolerance changes. This corresponds to the discussion in Chapter II, Part 3 about long term investment strategies and the lack of compatible data from the OSD calculators. Accordingly, the model calculates rates of return at a higher rate until age 67, then at a lower rate from 67 until 77. The following chart shows the model assumptions:

| Investment Preference | To age 67 | Ages 67-77 |
|-----------------------|-----------|------------|
| Conservative | 6% | 3% |
| Moderate | 8% | 4% |
| Optimistic | 10% | 5% |

The tree has the corresponding branches to the outcomes of the Redux side of the

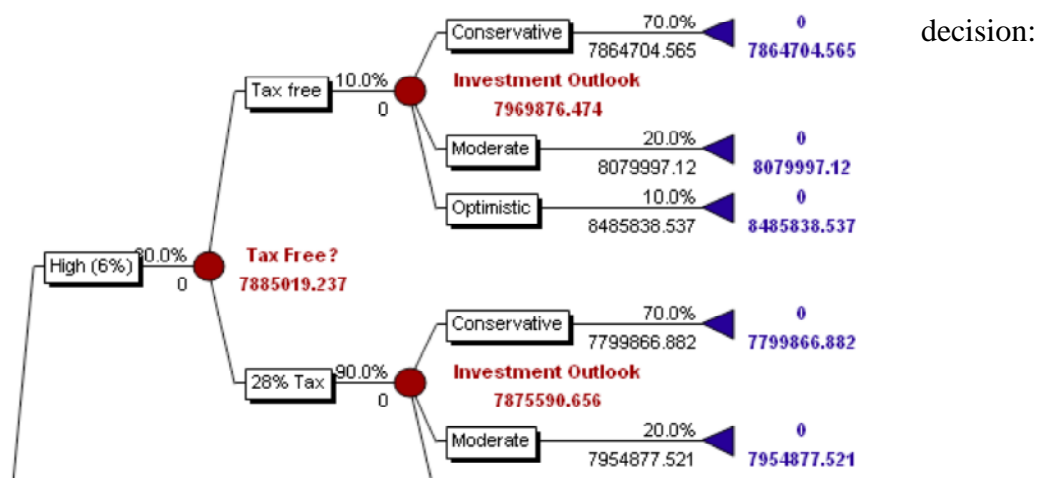


Figure 17: Decision Tree Redux Branch

This is just one small section of the Redux. Because of the two additional chance nodes (one which has 3 options), there are far more possible outcomes following the Redux uncertainty. Under the High 3, there are 24 possible outcomes, while the Redux produces 144 different possible outcomes, for a total of 168 possible outcomes. The Precision Tree model is designed to calculate all 168 outcomes, and then works backward through the tree based on the user's preference probabilities to calculate the expected value at each uncertainty and to ultimately determine the two final expected values at the decision node. In order to calculate all 168 outcomes simultaneously based on user inputs, the Precision Tree model in excel references another spreadsheet in excel which contains all of the calculations based on the user inputs of age at service year 15 and expected low and high ranks. Those inputs are enough to perform all of the spreadsheet calculations. The additional inputs for all of the preference probabilities go directly into the Precision Tree model itself.

Part 2: Spreadsheet / Precision Tree Calculations

In order to accurately calculate 168 outcomes simultaneously, the model must be capable of taking basic inputs and then calculating many different potential outputs. For ease of understanding and to ensure the correct logic at each step, the spreadsheet calculates in steps. We start with the math behind just the High 3 retirement calculations.

High 3

The basis for the High 3 calculation is the average base pay for the last three years of service multiplied by a factor of 2.5% per year of service. So at 20 years, it would be 50% of base pay, at 25 years it is 62.5%, and at 30 years it is 75%. For the spreadsheet, we let

x = retired rank base pay, 2011 pay scales (16+ for 20 yrs, 22+ for 25, 26+ for 30)

pr = Active Duty Pay Raise

n = years of service at retirement

Then:

$$RP_H (\text{Retirement Pay High 3}) = .025 * n * (x * (1 + pr)^{n-1})$$

The initial part of the formula, $.025 * n$, determines the multiplier for the base pay. The second half of the formula uses the initial value (x) and then multiplies it by the compound amount factor $(1 + pr)^{n-1}$. (de Neufville, 1990) This formula allows multiple simultaneous calculations; the only user input is the expected low and high retirement rank.

The next step is to calculate the cumulative pay by age 77. To calculate, we use the Capital Recovery Formula to define a stream of constant payments (RP_H). The value of a future sum is:

$$S = \sum R (1+r)^I = R[(1 + r)^N - 1]/r$$

Where S is the cumulative total, R is the initial constant payment, N is the number of payments (years) and r in this case is the inflation rate. (de Neufville) Applying this value to the model, we have:

$$\text{Cumulative total at 77} = 12 * RP_H * [(1+r)^{78-(a+n-15)} - 1] / r$$

where r = inflation rate, a = age at 15 years service. Because RP is the monthly pay, we multiply by 12 for annual pay because the second half of the calculation for the capital recovery formula is based on annual increases and payments. The value for the power of $N = (78-(a+n-15))$ is just a means to calculate the value based only on the user input of age at service year 15. The spreadsheet is designed to only require the high and low rank and age at year 15 to calculate all 24 possible outcomes. These outcomes are all calculated simultaneously and then linked to the Precision Tree model for the decision tree calculations (discussed later).

Redux

Similar to the High 3 calculations, the Redux calculation begins with the base pay at retirement. The same methodology is used to simulate the average of the last three years of service. This produces an outcome which provides a direct comparison to the High 3 calculation. The difference in the Redux is the fact that the multiplier is 2%/year for the first 20 years, and then 3.5%/year for the next 10 years of service. So at 20 years of service, the multiplier is 40%, at 25 years it is .575, and at 30 years it matches the .75 multiplier of the High 3 formula. To account for this, the model formula is:

$$RP_R (\text{Retirement Pay Redux}) = (.4 + .035(n-20)) * (x * (1+pr)^{n-15})$$

This calculation is essentially the same as the High 3 –it just allows for the multiplier to be .4 at 20 years of service and then increases by 3.5%/year of service. The second part of the formula is the compound amount factor used in the High 3 calculation.

Because the Redux pay scale “catches up” at age 62, there are a few more required calculations. First, we must calculate the cumulative total paid to the service member by age 61. To do this, we use the same formula from the High 3:

$$\text{Cumulative total at 61} = 12 * RP_R * [(1+r-.01)^{62-(a+n-15)} - 1] / r$$

This will be used to add to the pay from years 62-77 because the base pay changes at year 62. Next is to calculate the new base pay at year 62. This pay at age 62 equals the exact base pay at age 62 if the service member had opted for the High 3 retirement. So we use the formula:

$$RP_{62} = RP_H * (1+r)^{(63-(a+n-15))}$$

This takes the base pay calculation from the High 3 calculator and then applies for the compound amount factor to account for the annual increase in retirement pay due to inflation rate (r). We do not use r-.01 for this calculation because the proper amount is equal to the High 3, which equals inflation rate/CPI. This number is now the basis for the remaining total to age 77. So the total at age 77 is the sum at age 61 and the total from 62-77:

$$\text{Cumulative total at 77} = \text{Total at 61} + (12 * RP_{62} * [(1+r-.01)^{16} - 1] / (r-.01))$$

Again this is similar to the High 3 and uses the catch-up pay at age 62, then adjusts to CPI-1% until age 77.

The next step is to calculate the value of investing the \$30,000 CSB. The key assumption is that the service member will save and invest all the bonus pay; the only

preference probabilities for the user are the probability of investing tax free and the investment outlook (conservative, moderate, or optimistic). Based on previous analysis, the investment rate of return changes at age 67. To account for this, the model first calculates the total accumulated from the time of the bonus at service year 15 until the service member reaches the age of 67:

$$BV_{67} = \text{Value of \$30K at age 67} = (30000 - (30000 * tr) * ((1 + rr_1)^{(67-a)}))$$

tr = tax rate (either 0 for tax free or .28 for 28% tax)

rr₁ = Initial rate of return (to age 67). Cons = .06, Mod = .08, Opt = .1

rr₂ = Secondary rate of return (67-77). Cons = .03, Mod = .04, Opt = .05

This value then becomes the new base value to calculate to age 77. The formula is:

$$BV_{77} = \text{Value of \$30K at age 77} = BV_{67} * ((1 + rr_2)^{(10)})$$

The total value of each outcome is just the sum of the cumulative retirement pay under the Redux plan plus the total amount of the \$30K bonus invested until the age of 77. All of the numbers used are pre-tax for consistency, although the model could be easily modified to calculate after-tax values as well. For the Redux values, there are 144 different possible outcomes (for a total of 168). These possible outcomes are calculated and linked to the Precision Tree model.

Summary

While the spreadsheet calculations provide a great deal of information simultaneously, they do not provide the service member with much more information than what is provided by the OSD calculators. The true advantage and value of the model is to take a user's preference probabilities and calculate the expected value of each

decision by going backwards through the decision tree as explained in Part 1 of this chapter. The next Chapter will step through two different example scenarios to show how the combination of the spreadsheet calculations and decision tree model can help service members make the right decision based on their preference probabilities.

IV. Example Scenarios

Scenario 1: Major Wright

Major Wright is reaching his 15th year of service in 2011. He is 37 years old and will be 42 at the time of his potential 20 year retirement in 2016. He is trying to determine the best financial decision: should he take the \$30K bonus and the Redux retirement or should he elect the traditional High 3 retirement? In order to reach his decision, he needs to determine his preference probabilities for the following questions:

1. *What does he expect his low and high retirement ranks to be (if he stays in past 20 years)?* Answer: Maj Wright is already an O-5 select so he expects that at the 20 year point he will be an O-5. As an IDE in-residence graduate, he knows that he has a 20% chance to make O-6 if he stays in to 25 or 30 years. So his answer is 80% O-5 and 20% O-6. The model takes into account that if he stays in only until 20 years, he has a 100% probability of retiring at the lower (O-5) rank.

2. *What is his probable retirement timeline – what are his preference probabilities to retire at 20, 25, or 30 years?* Answer: He is planning on retiring at 20 years but there is a chance he stays in, depending on job outlook and career progression. He thinks there is a 70% chance that he retires at 20 years, a 20% chance of retiring around 25 years, and a 10% chance he stays in until 30 years.

3. *What does he think the average annual active duty pay raise will be over the next several years (until he retires) – low (2%) vs. high (4%)?* Answer: Maj Wright follows the news and is aware that the most recent pay raise was less than 2%. He does

not expect dramatic rise in pay, so his preference probability for this uncertainty is 90% for the lower (2%) rise in pay.

4. *What does he expect the average annual inflation rate will be over his lifetime – low (2%) vs. high (6%)?* Answer: Maj Wright knows that the CPI (the value used for retirement pay increase) averaged 2.35% from 2001 to 2010. He also knows that for the past two years there has been no increase in CPI (no retiree pay raise at all), and that the Congressional Budget Office estimates that from 2012-2015 the CPI is expected to be 1.6%, and only up to 1.9% from 2016-2019. Even though he knows that there is a possibility of inflation, he would rather use more conservative numbers and has an 80% preference for the low inflation rate over his lifetime.

5. *If he elects the \$30K bonus, what is the probability that he will be able to invest it tax free (either serving in combat zone or TSP investment)?* Answer: He is not in a combat zone right now, in fact he is at the Air Staff and it is unlikely that he will deploy or be deployed long enough to invest the bonus tax-free. He already maxes out his TSP, so he does not want to take credit for any tax advantage that the TSP could provide (because he is already receiving the advantage without the bonus). So his preference probability is a 100% chance of a 28% tax on the bonus.

6. *If he elects the \$30K bonus (and assuming he invests all of it), what is his investment outlook – conservative, moderate, or aggressive/optimistic?* Answer: He is conservative by nature and does not want to be overly optimistic with the gains he will achieve from the bonus (does not want to sway his decision with a faulty investment assumption or preference). He thinks it is most likely that he will achieve the

conservative rate of return of 6% until the age of 67 and 3% after the age of 67 – he gives this an 80% probability. He gives a 20% probability of the moderate rate of return of 8% until age 67 and 4% until age 77. He gives the more optimistic/aggressive rate of return a 0% probability.

In order to calculate the expected value of either decision, the basic inputs of the model are put into the spreadsheet. These inputs are low and high rank (O-5, O-6) and his age at service year 15, which is 37. All combinations of possible outputs are then computed by the excel spreadsheet model using the formulas explained in Chapter 3.

The following High 3 outcomes (highlighted) are calculated based on his inputs:

| | | | | | | | |
|------------------------------|--|---|--|--|--|-----------------------------|--|
| High 3 Calculations/Outcomes | | A= Years of service (A1 = 20 ,A2 = 25 ,A3=30) | | B= Active duty pay raise, B1=4%, B2=2% | | C= Inflation (C1=6%, C2=2%) | |
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|---|--|
| A = Years of service (A1 = 20, A2 = 25, A3=30) | |
| B = Active duty pay raise, B1=4%, B2=2% | |
| C = Inflation (C1=6%, C2=2%) | |
| D = Taxes on \$30K (D1 = Tax free, D2 = 28%) | |
| E = Investment Return (E1 = cons, E2 = mod, E3 = opt) | |

| Low Rank | | | | | | | | High Rank | | | | | | | |
|----------|--------------------|------------------|-----------|------------------|----------------|----------------|-------------|-----------|--------------------|------------------|-----------|------------------|----------------|----------------|--------------|
| O-5 | | | | | | | | O-6 | | | | | | | |
| | Initial Retirement | Cumulative at 61 | Pay at 62 | Cumulative at 77 | \$30K Accum 67 | \$30K Accum 77 | 77+\$30K | | Initial Retirement | Cumulative at 61 | Pay at 62 | Cumulative at 77 | \$30K Accum 67 | \$30K Accum 77 | 77+\$30K |
| A1B1C1D1 | \$3,718 | \$1,475,442 | \$15,801 | \$5,961,274 | \$172,305 | \$231,563 | \$6,192,837 | A1B1C1D1 | \$0 | \$0 | \$0 | \$0 | \$172,305 | \$231,563 | \$231,563 |
| A1B1C1D1 | \$3,718 | \$1,475,442 | \$15,801 | \$5,961,274 | \$301,880 | \$446,856 | \$6,408,129 | A1B1C1D1 | \$0 | \$0 | \$0 | \$0 | \$301,880 | \$446,856 | \$446,856 |
| A1B1C1D1 | \$3,718 | \$1,475,442 | \$15,801 | \$5,961,274 | \$523,482 | \$952,697 | \$6,813,971 | A1B1C1D1 | \$0 | \$0 | \$0 | \$0 | \$523,482 | \$952,697 | \$952,697 |
| A1B1C1D2 | \$3,718 | \$1,475,442 | \$15,801 | \$5,961,274 | \$124,059 | \$166,725 | \$6,127,999 | A1B1C1D2 | \$0 | \$0 | \$0 | \$0 | \$124,059 | \$166,725 | \$166,725 |
| A1B1C1D2 | \$3,718 | \$1,475,442 | \$15,801 | \$5,961,274 | \$217,353 | \$321,736 | \$6,283,010 | A1B1C1D2 | \$0 | \$0 | \$0 | \$0 | \$217,353 | \$321,736 | \$321,736 |
| A1B1C1D2 | \$3,718 | \$1,475,442 | \$15,801 | \$5,961,274 | \$376,907 | \$613,942 | \$6,575,215 | A1B1C1D2 | \$0 | \$0 | \$0 | \$0 | \$376,907 | \$613,942 | \$613,942 |
| A1B1C2D1 | \$3,718 | \$982,514 | \$7,045 | \$2,441,469 | \$172,305 | \$231,563 | \$2,673,032 | A1B1C2D1 | \$0 | \$0 | \$0 | \$0 | \$172,305 | \$231,563 | \$231,563 |
| A1B1C2D1 | \$3,718 | \$982,514 | \$7,045 | \$2,441,469 | \$301,880 | \$446,856 | \$2,888,324 | A1B1C2D1 | \$0 | \$0 | \$0 | \$0 | \$301,880 | \$446,856 | \$446,856 |
| A1B1C2D1 | \$3,718 | \$982,514 | \$7,045 | \$2,441,469 | \$523,482 | \$952,697 | \$3,294,166 | A1B1C2D1 | \$0 | \$0 | \$0 | \$0 | \$523,482 | \$952,697 | \$952,697 |
| A1B1C2D2 | \$3,718 | \$982,514 | \$7,045 | \$2,441,469 | \$124,059 | \$166,725 | \$2,608,194 | A1B1C2D2 | \$0 | \$0 | \$0 | \$0 | \$124,059 | \$166,725 | \$166,725 |
| A1B1C2D2 | \$3,718 | \$982,514 | \$7,045 | \$2,441,469 | \$217,353 | \$321,736 | \$2,763,205 | A1B1C2D2 | \$0 | \$0 | \$0 | \$0 | \$217,353 | \$321,736 | \$321,736 |
| A1B1C2D2 | \$3,718 | \$982,514 | \$7,045 | \$2,441,469 | \$376,907 | \$613,942 | \$3,055,410 | A1B1C2D2 | \$0 | \$0 | \$0 | \$0 | \$376,907 | \$613,942 | \$613,942 |
| A1B2C1D1 | \$3,374 | \$1,338,925 | \$14,339 | \$5,409,700 | \$172,305 | \$231,563 | \$5,641,264 | A1B2C1D1 | \$0 | \$0 | \$0 | \$0 | \$172,305 | \$231,563 | \$231,563 |
| A1B2C1D1 | \$3,374 | \$1,338,925 | \$14,339 | \$5,409,700 | \$301,880 | \$446,856 | \$5,856,556 | A1B2C1D1 | \$0 | \$0 | \$0 | \$0 | \$301,880 | \$446,856 | \$446,856 |
| A1B2C1D1 | \$3,374 | \$1,338,925 | \$14,339 | \$5,409,700 | \$523,482 | \$952,697 | \$6,262,398 | A1B2C1D1 | \$0 | \$0 | \$0 | \$0 | \$523,482 | \$952,697 | \$952,697 |
| A1B2C1D2 | \$3,374 | \$1,338,925 | \$14,339 | \$5,409,700 | \$124,059 | \$166,725 | \$5,576,426 | A1B2C1D2 | \$0 | \$0 | \$0 | \$0 | \$124,059 | \$166,725 | \$166,725 |
| A1B2C1D2 | \$3,374 | \$1,338,925 | \$14,339 | \$5,409,700 | \$217,353 | \$321,736 | \$5,731,437 | A1B2C1D2 | \$0 | \$0 | \$0 | \$0 | \$217,353 | \$321,736 | \$321,736 |
| A1B2C1D2 | \$3,374 | \$1,338,925 | \$14,339 | \$5,409,700 | \$376,907 | \$613,942 | \$6,023,642 | A1B2C1D2 | \$0 | \$0 | \$0 | \$0 | \$376,907 | \$613,942 | \$613,942 |
| A1B2C2D1 | \$3,374 | \$891,606 | \$6,393 | \$2,215,569 | \$172,305 | \$231,563 | \$2,447,132 | A1B2C2D1 | \$0 | \$0 | \$0 | \$0 | \$172,305 | \$231,563 | \$231,563 |
| A1B2C2D1 | \$3,374 | \$891,606 | \$6,393 | \$2,215,569 | \$301,880 | \$446,856 | \$2,662,425 | A1B2C2D1 | \$0 | \$0 | \$0 | \$0 | \$301,880 | \$446,856 | \$446,856 |
| A1B2C2D1 | \$3,374 | \$891,606 | \$6,393 | \$2,215,569 | \$523,482 | \$952,697 | \$3,068,266 | A1B2C2D1 | \$0 | \$0 | \$0 | \$0 | \$523,482 | \$952,697 | \$952,697 |
| A1B2C2D2 | \$3,374 | \$891,606 | \$6,393 | \$2,215,569 | \$124,059 | \$166,725 | \$2,382,295 | A1B2C2D2 | \$0 | \$0 | \$0 | \$0 | \$124,059 | \$166,725 | \$166,725 |
| A1B2C2D2 | \$3,374 | \$891,606 | \$6,393 | \$2,215,569 | \$217,353 | \$321,736 | \$2,537,305 | A1B2C2D2 | \$0 | \$0 | \$0 | \$0 | \$217,353 | \$321,736 | \$321,736 |
| A1B2C2D2 | \$3,374 | \$891,606 | \$6,393 | \$2,215,569 | \$376,907 | \$613,942 | \$2,829,511 | A1B2C2D2 | \$0 | \$0 | \$0 | \$0 | \$376,907 | \$613,942 | \$613,942 |
| A2B1C1D1 | \$7,076 | \$1,832,224 | \$19,538 | \$7,378,872 | \$172,305 | \$231,563 | \$7,610,435 | A2B1C1D1 | \$8,057 | \$2,086,187 | \$22,246 | \$8,401,652 | \$172,305 | \$231,563 | \$8,633,215 |
| A2B1C1D1 | \$7,076 | \$1,832,224 | \$19,538 | \$7,378,872 | \$301,880 | \$446,856 | \$7,825,728 | A2B1C1D1 | \$8,057 | \$2,086,187 | \$22,246 | \$8,401,652 | \$301,880 | \$446,856 | \$8,848,508 |
| A2B1C1D1 | \$7,076 | \$1,832,224 | \$19,538 | \$7,378,872 | \$523,482 | \$952,697 | \$8,231,569 | A2B1C1D1 | \$8,057 | \$2,086,187 | \$22,246 | \$8,401,652 | \$523,482 | \$952,697 | \$9,254,349 |
| A2B1C1D2 | \$7,076 | \$1,832,224 | \$19,538 | \$7,378,872 | \$124,059 | \$166,725 | \$7,545,598 | A2B1C1D2 | \$8,057 | \$2,086,187 | \$22,246 | \$8,401,652 | \$124,059 | \$166,725 | \$8,568,377 |
| A2B1C1D2 | \$7,076 | \$1,832,224 | \$19,538 | \$7,378,872 | \$217,353 | \$321,736 | \$7,700,608 | A2B1C1D2 | \$8,057 | \$2,086,187 | \$22,246 | \$8,401,652 | \$217,353 | \$321,736 | \$8,723,388 |
| A2B1C1D2 | \$7,076 | \$1,832,224 | \$19,538 | \$7,378,872 | \$376,907 | \$613,942 | \$7,992,814 | A2B1C1D2 | \$8,057 | \$2,086,187 | \$22,246 | \$8,401,652 | \$376,907 | \$613,942 | \$9,015,594 |
| A2B1C2D1 | \$7,076 | \$1,366,778 | \$10,558 | \$3,553,321 | \$172,305 | \$231,563 | \$3,784,884 | A2B1C2D1 | \$8,057 | \$1,556,226 | \$12,022 | \$4,045,844 | \$172,305 | \$231,563 | \$4,277,407 |
| A2B1C2D1 | \$7,076 | \$1,366,778 | \$10,558 | \$3,553,321 | \$301,880 | \$446,856 | \$4,000,176 | A2B1C2D1 | \$8,057 | \$1,556,226 | \$12,022 | \$4,045,844 | \$301,880 | \$446,856 | \$4,492,699 |
| A2B1C2D1 | \$7,076 | \$1,366,778 | \$10,558 | \$3,553,321 | \$523,482 | \$952,697 | \$4,406,018 | A2B1C2D1 | \$8,057 | \$1,556,226 | \$12,022 | \$4,045,844 | \$523,482 | \$952,697 | \$4,898,541 |
| A2B1C2D2 | \$7,076 | \$1,366,778 | \$10,558 | \$3,553,321 | \$124,059 | \$166,725 | \$3,720,046 | A2B1C2D2 | \$8,057 | \$1,556,226 | \$12,022 | \$4,045,844 | \$124,059 | \$166,725 | \$4,212,569 |
| A2B1C2D2 | \$7,076 | \$1,366,778 | \$10,558 | \$3,553,321 | \$217,353 | \$321,736 | \$3,875,057 | A2B1C2D2 | \$8,057 | \$1,556,226 | \$12,022 | \$4,045,844 | \$217,353 | \$321,736 | \$4,367,580 |
| A2B1C2D2 | \$7,076 | \$1,366,778 | \$10,558 | \$3,553,321 | \$376,907 | \$613,942 | \$4,167,263 | A2B1C2D2 | \$8,057 | \$1,556,226 | \$12,022 | \$4,045,844 | \$376,907 | \$613,942 | \$4,669,786 |
| A2B2C1D1 | \$5,827 | \$1,508,853 | \$16,090 | \$6,076,567 | \$172,305 | \$231,563 | \$6,308,130 | A2B2C1D1 | \$6,635 | \$1,717,993 | \$18,320 | \$6,918,836 | \$172,305 | \$231,563 | \$7,150,399 |
| A2B2C1D1 | \$5,827 | \$1,508,853 | \$16,090 | \$6,076,567 | \$301,880 | \$446,856 | \$6,523,423 | A2B2C1D1 | \$6,635 | \$1,717,993 | \$18,320 | \$6,918,836 | \$301,880 | \$446,856 | \$7,365,691 |
| A2B2C1D1 | \$5,827 | \$1,508,853 | \$16,090 | \$6,076,567 | \$523,482 | \$952,697 | \$6,929,264 | A2B2C1D1 | \$6,635 | \$1,717,993 | \$18,320 | \$6,918,836 | \$523,482 | \$952,697 | \$7,771,533 |
| A2B2C1D2 | \$5,827 | \$1,508,853 | \$16,090 | \$6,076,567 | \$124,059 | \$166,725 | \$6,243,293 | A2B2C1D2 | \$6,635 | \$1,717,993 | \$18,320 | \$6,918,836 | \$124,059 | \$166,725 | \$7,085,561 |
| A2B2C1D2 | \$5,827 | \$1,508,853 | \$16,090 | \$6,076,567 | \$217,353 | \$321,736 | \$6,396,303 | A2B2C1D2 | \$6,635 | \$1,717,993 | \$18,320 | \$6,918,836 | \$217,353 | \$321,736 | \$7,240,572 |
| A2B2C1D2 | \$5,827 | \$1,508,853 | \$16,090 | \$6,076,567 | \$376,907 | \$613,942 | \$6,690,509 | A2B2C1D2 | \$6,635 | \$1,717,993 | \$18,320 | \$6,918,836 | \$376,907 | \$613,942 | \$7,532,777 |
| A2B2C2D1 | \$5,827 | \$1,125,554 | \$8,695 | \$2,926,191 | \$172,305 | \$231,563 | \$3,157,755 | A2B2C2D1 | \$6,635 | \$1,281,566 | \$9,900 | \$3,331,789 | \$172,305 | \$231,563 | \$3,563,352 |
| A2B2C2D1 | \$5,827 | \$1,125,554 | \$8,695 | \$2,926,191 | \$301,880 | \$446,856 | \$3,373,047 | A2B2C2D1 | \$6,635 | \$1,281,566 | \$9,900 | \$3,331,789 | \$301,880 | \$446,856 | \$3,778,644 |
| A2B2C2D1 | \$5,827 | \$1,125,554 | \$8,695 | \$2,926,191 | \$523,482 | \$952,697 | \$3,778,889 | A2B2C2D1 | \$6,635 | \$1,281,566 | \$9,900 | \$3,331,789 | \$523,482 | \$952,697 | \$4,184,486 |
| A2B2C2D2 | \$5,827 | \$1,125,554 | \$8,695 | \$2,926,191 | \$124,059 | \$166,725 | \$3,092,917 | A2B2C2D2 | \$6,635 | \$1,281,566 | \$9,900 | \$3,331,789 | \$124,059 | \$166,725 | \$3,498,514 |
| A2B2C2D2 | \$5,827 | \$1,125,554 | \$8,695 | \$2,926,191 | \$217,353 | \$321,736 | \$3,247,928 | A2B2C2D2 | \$6,635 | \$1,281,566 | \$9,900 | \$3,331,789 | \$217,353 | \$321,736 | \$3,653,525 |
| A2B2C2D2 | \$5,827 | \$1,125,554 | \$8,695 | \$2,926,191 | \$376,907 | \$613,942 | \$3,540,133 | A2B2C2D2 | \$6,635 | \$1,281,566 | \$9,900 | \$3,331,789 | \$376,907 | \$613,942 | \$3,945,730 |
| A3B1C1D1 | \$11,229 | \$1,694,821 | \$21,316 | \$7,746,130 | \$172,305 | \$231,563 | \$7,977,693 | A3B1C1D1 | \$13,761 | \$2,076,953 | \$26,122 | \$9,492,650 | \$172,305 | \$231,563 | \$9,724,213 |
| A3B1C1D1 | \$11,229 | \$1,694,821 | \$21,316 | \$7,746,130 | \$301,880 | \$446,856 | \$8,192,995 | A3B1C1D1 | \$13,761 | \$2,076,953 | \$26,122 | \$9,492,650 | \$301,880 | \$446,856 | \$9,939,505 |
| A3B1C1D1 | \$11,229 | \$1,694,821 | \$21,316 | \$7,746,130 | \$523,482 | \$952,697 | \$8,598,827 | A3B1C1D1 | \$13,761 | \$2,076,953 | \$26,122 | \$9,492,650 | \$523,482 | \$952,697 | \$10,345,347 |
| A3B1C1D2 | \$11,229 | \$1,694,821 | \$21,316 | \$7,746,130 | \$124,059 | \$166,725 | \$7,912,855 | A3B1C1D2 | \$13,761 | \$2,076,953 | \$26,122 | \$9,492,650 | \$124,059 | \$166,725 | \$9,669,375 |
| A3B1C1D2 | \$11,229 | \$1,694,821 | \$21,316 | \$7,746,130 | \$217,353 | \$321,736 | \$8,067,866 | A3B1C1D2 | \$13,761 | \$2,076,953 | \$26,122 | \$9,492,650 | \$217,353 | \$321,736 | \$9,814,386 |
| A3B1C1D2 | \$11,229 | \$1,694,821 | \$21,316 | \$7,746,130 | \$376,907 | \$613,942 | \$8,360,071 | A3B1C1D2 | \$13,761 | \$2,076,953 | \$26,122 | \$9,492,650 | \$376,907 | \$613,942 | \$10,106,591 |
| A3B1C2D1 | \$11,229 | \$1,409,742 | \$13,962 | \$4,301,121 | \$172,305 | \$231,563 | \$4,532,684 | A3B1C2D1 | \$13,761 | \$1,727,596 | \$17,110 | \$5,270,894 | \$172,305 | | |

The spreadsheet details all of the possible outcomes for Maj Wright based on his age and rank inputs. These outcomes then go into the decision tree model to calculate the expected values. There are more inputs specific to the decision tree model; these inputs are Maj Wright's preference probabilities previously discussed in this section:

| Inputs | | | |
|--------------------------|---------------------|--------------------|--------------------------|
| Retirement timeline | 20yr 0.7 | 25yr 0.2 | 30 yr 0.1 |
| Rank | High 0.2 | Low 0.8 | |
| Active Duty Pay Increase | 4% 0.1 | 2% 0.9 | |
| Inflation Rate | 6% 0.2 | 2% 0.8 | |
| 30K Bonus Taxes | Tax Free 0 | 28% Tax 1 | |
| 30K Bonus Investment | Cons (6%/3%) 0.8 | Mod (8%/4%) 0.2 | Optimistic (10%/5%) 0 |

Figure 20: Preference Probability Inputs

First we look at the impact of the combination of outcomes and preference probabilities for the High 3 decision. Because of the relative size of the tree we will only follow a few sections to explain the operation of the model.

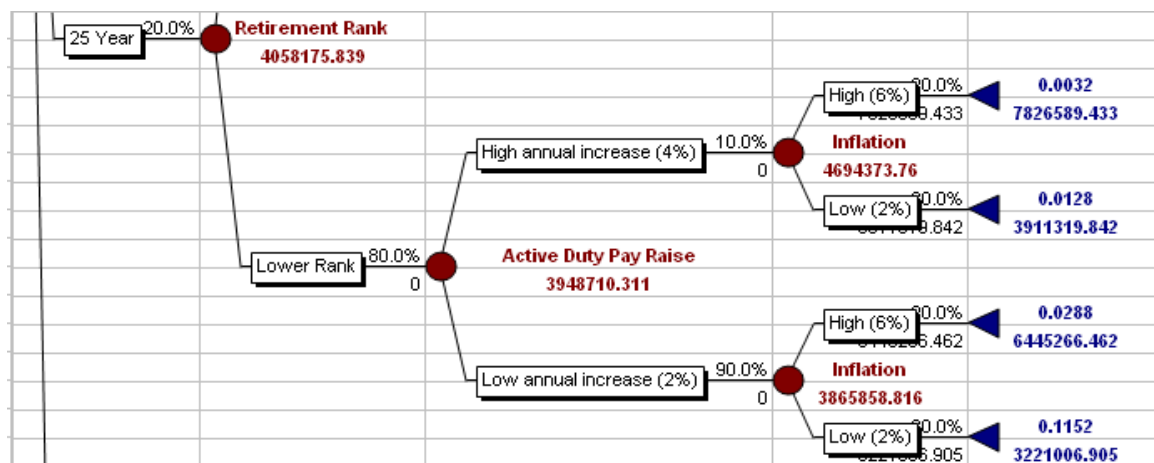


Figure 21: Scenario Decision Tree (High 3 Outcomes)

There are two numbers in the far right column. The set of top numbers are the probabilities of that particular outcome. For example, the probability of Maj Wright retiring at 25 years (20%) as an O-5 (80%) with a high annual increase in pay (10%) and a high CPI after retirement (20%) is .32%; $.2 \times .8 \times .1 \times .2 = .0032$. The number below is the outcome if all of those variables were 100% true – so if all of that came true, his cumulative retirement pay at age 77 would be \$7.83M; this number comes directly from the outcomes calculated in the spreadsheet. Moving backward through the tree is the expected value of the inflation node – \$4.69M. This is the weighted expected value from the preference probabilities for inflation only – so for Maj Wright it is 20% \$7.83M and 80% \$3.91M. The simple math then is $.2 \times \$7.83 + .8 \times \$3.91 = \$4.69\text{M}$. The tree continues to work backwards in this manner, calculating new expected values based on the local weights at each node. Ultimately the High 3 expected value is given:

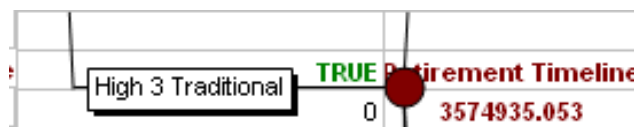


Figure 22: Scenario Decision Tree (High 3 Decision)

Simultaneously the expected values for the Redux option are calculated. The Redux calculations are similar but include the preference probabilities for the taxable amount of the bonus and the rate of return on investment. The Precision Tree model, after determining the correct decision, places a 0 in place of the global probabilities. Because the Redux does not have the higher expected value (as we will see), the probabilities for the Redux outcomes are 0. The local expected values are still calculated and shown:

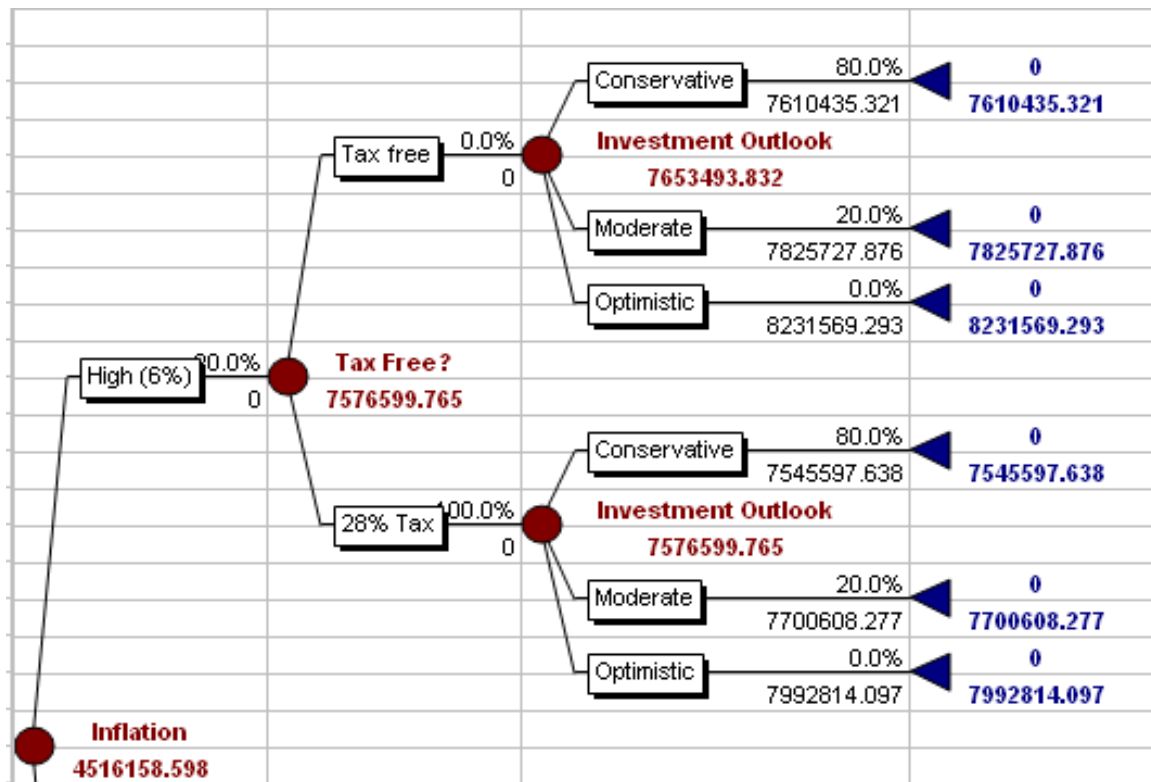


Figure 23: Scenario Decision Tree (Redux Outcomes)

An interesting note is the 100% probability that Maj Wright has for tax free investment – so the value of the investment outlook under 28% tax is the same as the next value working through the tree backwards -- \$7.57M. The tree continues to work backward until the expected value for the Redux decision is calculated:

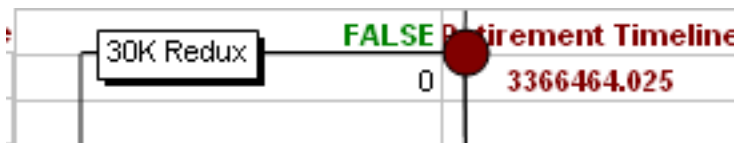


Figure 24: Scenario Decision Tree (Redux Decision)

So for Maj Wright, the expected value of the Redux decision is \$3.36M. The model also makes the decision clear -- “FALSE” indicates this is not the correct decision – the “TRUE” following the High 3 branch indicates the correct decision. The value is easy to calculate – simply the difference between the two decisions, $\$3.57\text{M} - \$3.37\text{M} = \$0.2\text{M}$. A full analysis for Maj Wright could show the sensitivity of some of his preferences – for example, if he could invest the bonus tax free, would that change his decision, and if so, at what preference probability would the decision change. This type of sensitivity analysis will be discussed in the next section.

Scenario 2:

Technical Sergeant Smith is 33 years old and is also at his 15 year decision point. He expects to make MSgt within the next two years and hopes that he will someday be promoted to Senior Master Sergeant. Again, these are the inputs for the spreadsheet previously discussed for Maj Wright. TSgt Smith’s preference probabilities are as follows:

1. Retirement Rank: 70% MSgt, 30% SMSgt
2. Retirement timeline: 50% 20 years, 50% 25 years, 0% 30 years
3. Annual active duty pay raise: 80% low, 20% high
4. Expected Inflation rate: 70% low, 30% high
5. Tax free savings: 50% tax free, 50% taxed at 28%

6. Investment outlook: 80% conservative, 20% moderate

The model calculates a new set of 168 outcomes given TSgt Smith's inputs of retiring as a MSgt or SMSgt and his age of 33 at the 15 year service point. These new outcomes are fed into the decision tree. The tree is updated with TSgt Smith's preference probabilities, and the final expected values are \$2.85M for the Redux, and \$2.80M for High 3. In other words, given his inputs and preference probabilities, TSgt Smith will make \$50,000 more under the Redux plan, so unlike Maj Wright, TSgt Smith would be better to take the \$30K bonus as long as he plans to save/invest the entire amount in accordance with the model assumption.

Part 2: Sensitivity Analysis

The purpose of sensitivity analysis is to provide the user with additional information regarding the decision. Sometimes, key factors can be identified which provide more of an impact on the decision, and therefore more attention should be paid to them or more resources devoted to determine the most accurate likelihood. Also, strictly following the expected value for a decision might not always be the correct answer. If one of the answers includes a very low probability of a very high value outcome, it might have a higher overall expected value, but will not yield as consistent results as the other option. For these reasons and more it is always best to conduct sensitivity analysis on the primary decision.

Technical Sergeant Smith

We begin with an analysis of TSgt Smith's results because there was only a \$10K difference between the two the expected values. First we look at the impact of changing his preference probabilities for each of the uncertainties on the overall expected value.

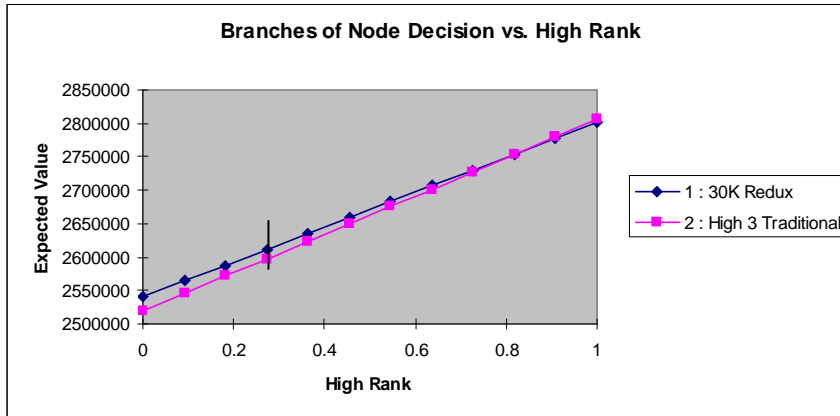


Figure 25: Enlisted Sensitivity to Rank

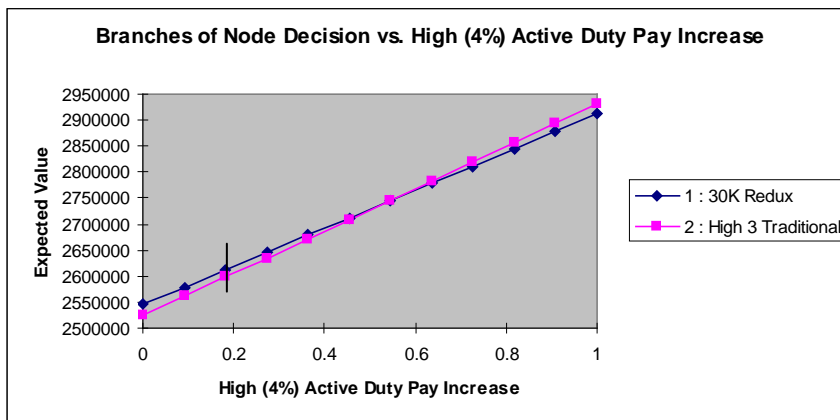


Figure 26: Enlisted Sensitivity to Pay Increase

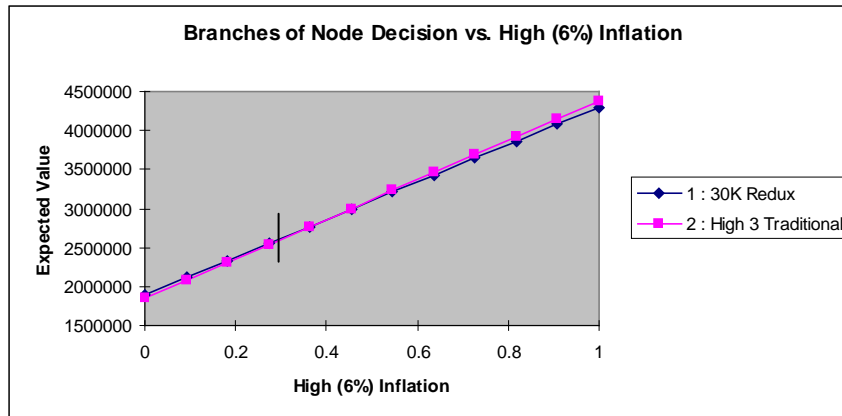


Figure 27: Enlisted Sensitivity to Inflation

The sensitivity analysis for the above uncertainties are all similar – as the likelihoods for higher rank, high annual active duty pay raise, and high inflation increase, the expected values all increase. Additionally, the decision with the resulting higher expected value also changes from Redux to High 3 at different points as can be seen in the charts. For example, in Figure 27, we can see that as TSgt Smith’s preference probability for high inflation increases, the expected value increases as well regardless of the decision he makes. However, if he is interested in maximizing the EV, then at approximately 50% preference for higher inflation, his proper retirement plan decision changes from Redux to the High 3 plan. In reality, for an economic factor like inflation TSgt Smith is probably not going to receive any new information that would cause him to change his preference probability. For a factor like tax-free investment, however, it is very possible that he could receive new information (like a deployment to a combat zone) that could certainly change his likelihood (Figure28). The power of the sensitivity analysis is to show the user at what point the proper decision would change based on new information.

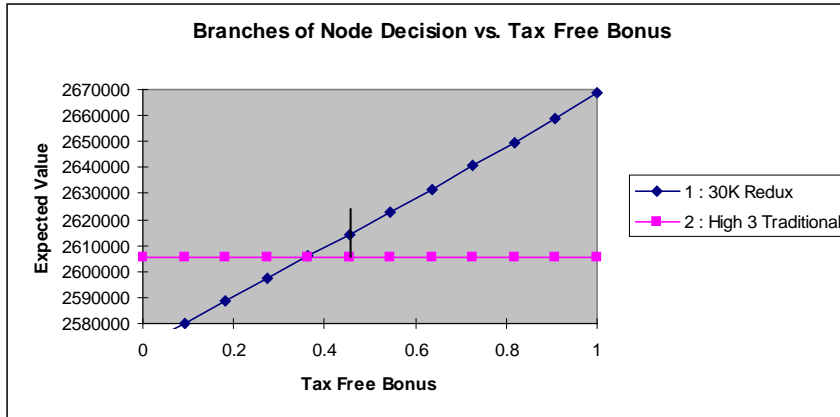


Figure 28: Enlisted Sensitivity to Tax Free Bonus

The tax on the bonus uncertainty is slightly different than the economic factors previously discussed. As shown above, the expected value does not change for High 3. The analysis shows how if the bonus is taxed and all other uncertainties remain constant according to TSgt Smith's preference probabilities, then the High 3 is the correct decision (higher EV). At approximately 40% probability of tax free, the decision changes to Redux.

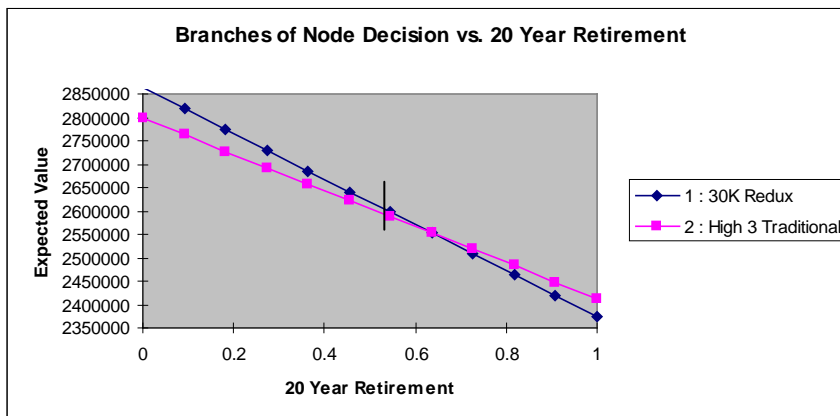


Figure 29: Enlisted Sensitivity to Retirement Timeline

The above uncertainty for retirement timeline only varies the choice between 0% probability of 20 year retirement and 100% probability of 25 year retirement to 100% probability of 20 year retirement and 0% probability of 25 year. EV decreases as the probability of a 20 year retirement increases, and the decision changes to High 3 the more likely it is that TSgt retires at 20 years. So if TSgt Smith becomes more certain that he will retire at 20 years (60% or higher), then his higher EV decision changes to the High 3 plan.

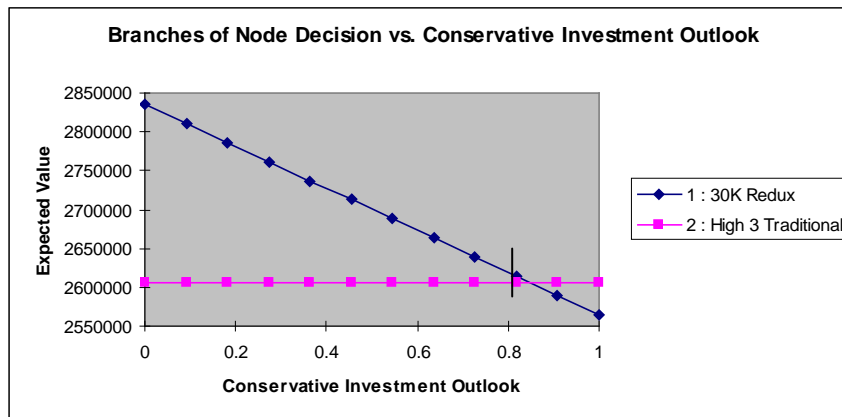


Figure 30: Enlisted Sensitivity to Investment Outlook

The above chart compares conservative vs. moderate investment outlook. As TSgt's preference for a conservative rate of return increases, the EV for the Redux plan decreases while the High 3 plan remains unchanged. Just past his preference probability of 80%, the High 3 plan produces the higher expected value.

A tornado diagram is helpful in depicting which of the uncertainties have the largest impact on the expected value and the overall decision and which uncertainties are

relatively negligible. The first tornado diagram compares the uncertainties to the resultant EV:

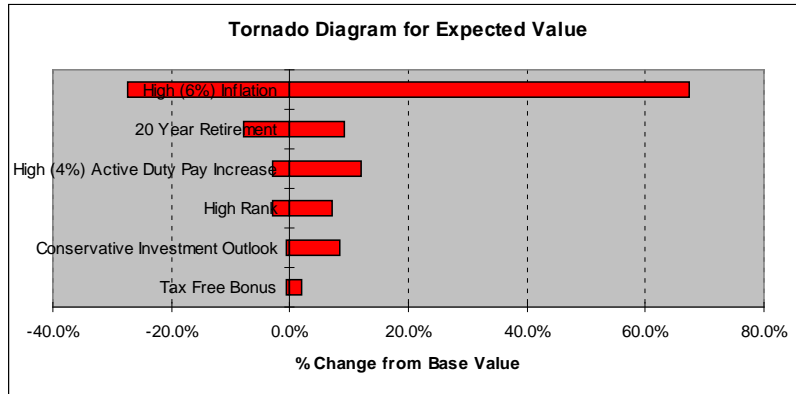


Figure 31: Enlisted Tornado Diagram for Expected Value

The diagram shows that the inflation uncertainty has the greatest impact on the expected value. From the base value of 30% for high inflation, decreasing the likelihood will decrease the EV by over 20%, and as high inflation likelihood increases, EV increases by over 60%. None of the other uncertainties have nearly as much impact, with the tax free uncertainty being the least impacting on EV.

While the previous tornado diagram shows how EV can be affected, it is not particularly helpful to TSgt Smith, except in determining what the overall value of his retirement will be. The next tornado diagram compares each variable to the difference in EV between Redux and High 3:

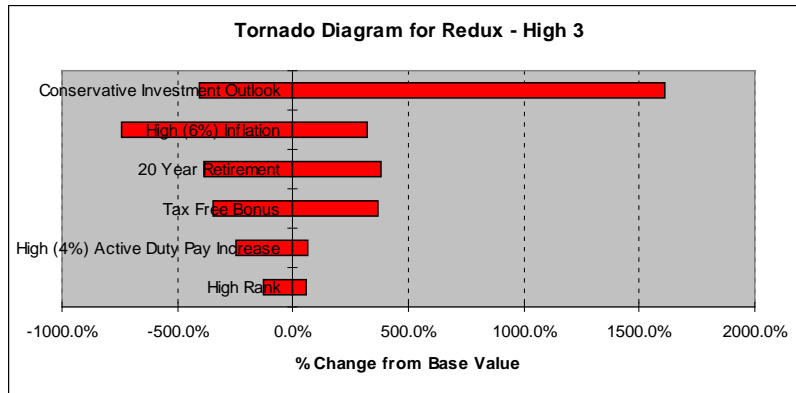


Figure 32: Enlisted Tornado Diagram for Decision Basis

Inflation remains important as the second-highest factor, but the most important variable is the investment outlook – becoming more conservative (from 80% to 100%) means a negative change in the difference between Redux and High 3; in this case because the values are so close, negative means that the High 3 is the decision with the highest value. As TSgt Smith’s preference for a conservative investment outlook decreases, the EV difference increases dramatically in favor of the Redux plan. The likelihood for rank at retirement has the least impact on difference in EV between the two plans.

Major Wright

Maj Wright’s preference probabilities are somewhat different than TSgt Smith’s probabilities. The EV for his decision is larger for the High 3 than for the Redux. Like it did for TSgt Smith, the sensitivity analysis helps illuminate the impact of his preference probabilities. Each analysis is similar to the sensitivity analysis charts of TSgt Smith:

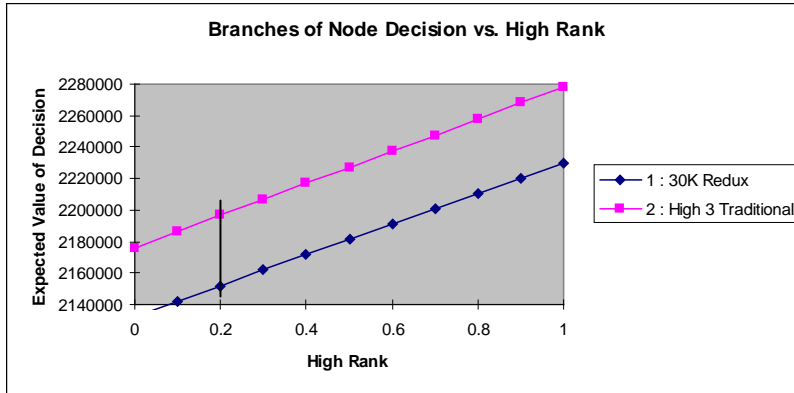


Figure 33: Officer Sensitivity to Rank

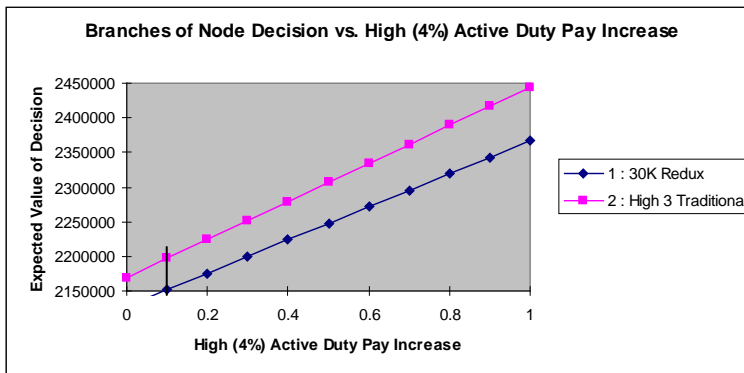


Figure 34: Officer Sensitivity to Pay Increase

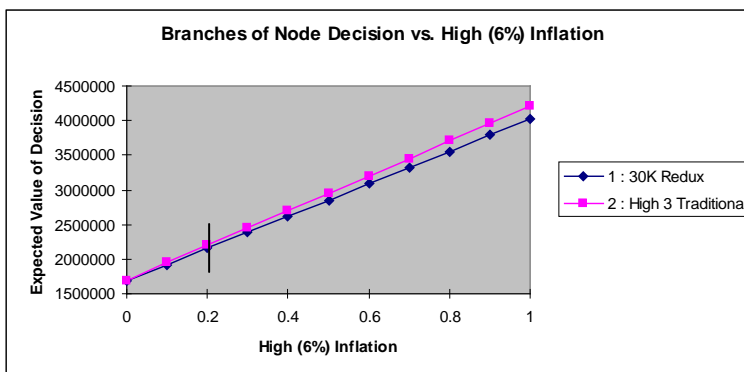


Figure 35: Officer Sensitivity to Inflation

The results of the uncertainties are similar to that of TSgt Smith's – EV increases as the likelihoods for High Rank, Pay Raise, and Inflation all increase. Unlike TSgt Smith's model, however, it can be said that the decision for High 3 is strictly dominant for each uncertainty – meaning that when all other variables are held constant, the greater EV does not change from High 3 across the entire range of probabilities for the specific uncertainty.

The tax free bonus uncertainty is also similar, but deserves attention because of Major Wright's preference probability of 0%. If he were more likely to expect tax-free bonus pay (if he were to be deployed to combat zone or was not currently investing in the TSP), then at approximately 50%, his correct decision is actually the Redux and investment of the \$30K bonus:

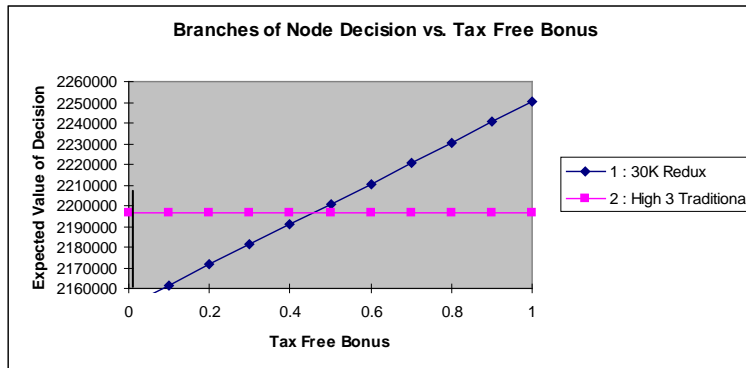


Figure 36: Officer Sensitivity to Tax Free Bonus

Maj Wright intends to retire at 20 years – and if so the correct decision is the High 3 plan. As his probability of retiring after 20 years increases, the Redux becomes a better decision.

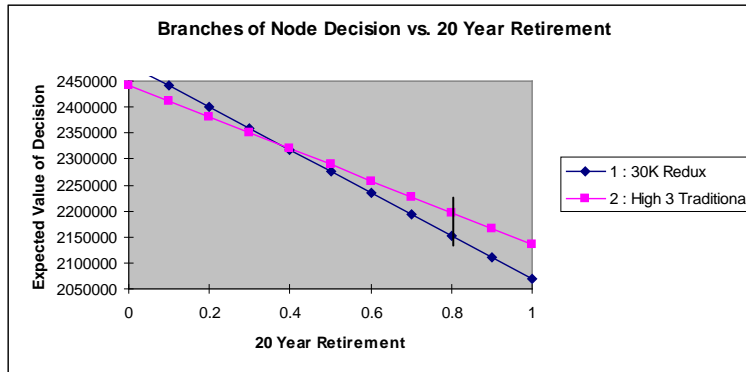


Figure 37: Officer Sensitivity to Retirement Timeline

Finally, the investment outlook favors the High 3 at Maj Wright's preference probability of .8. As this decreases, the Redux plan becomes the best decision (<.6).

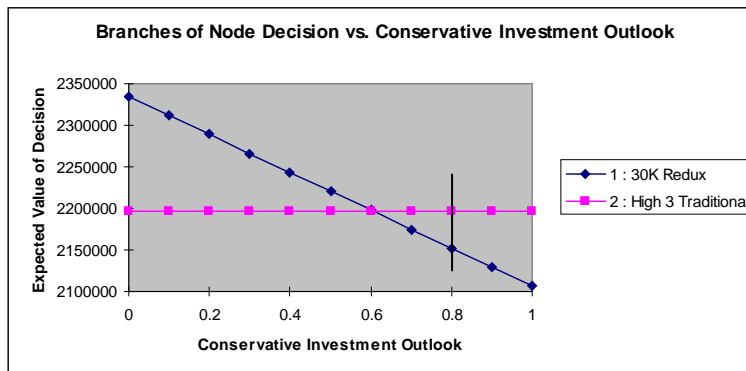


Figure 38: Officer Sensitivity to Investment Outlook

The sensitivity analysis for each uncertainty shows that in some cases the High 3 retirement plan is strictly dominant – meaning that varying each uncertainty while holding the others constant, the proper decision of High 3 producing the highest EV does not change. While true when varying a single uncertainty, we can also use a two-way

sensitivity analysis – varying two different uncertainties simultaneously. When the uncertainties for both the tax free bonus and the investment outlook are varied, Maj Wright’s highest EV decision changes from High 3 to Redux. The following table shows this impact:

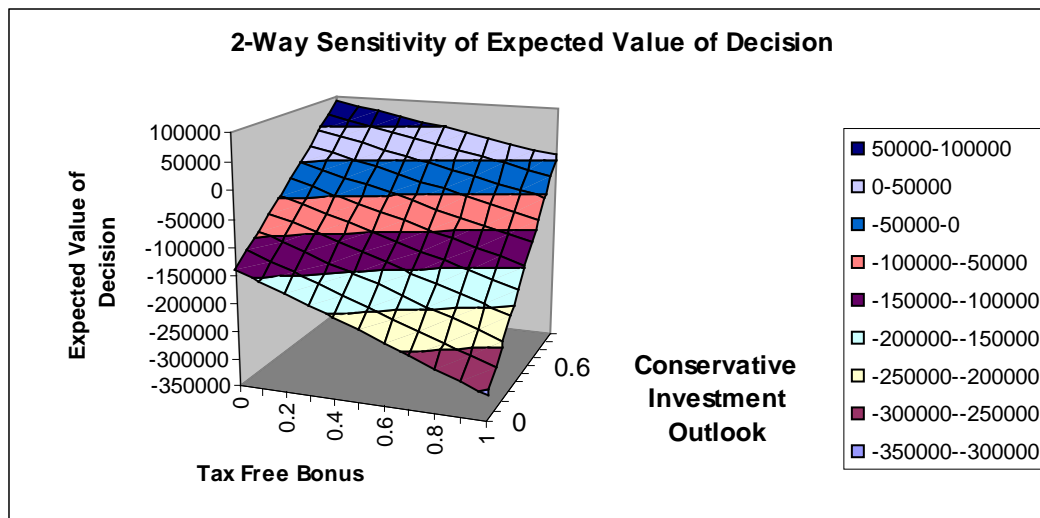


Figure 39: Officer 2-Way Sensitivity (Tax Free, Investment Outlook)

In this chart, the positive numbers on the left side of the chart indicate the greater EV for the High 3 decision, while the negative numbers indicate the greater EV for the Redux decision. The two-way sensitivity shows that if Maj Wright were to change two of his preferences simultaneously – to a moderate investment outlook of 8% / 4% returns and a tax-free income, his decision changes to Redux and the difference in EV is over \$300,000 difference in favor of the Redux plan.

The tornado diagram details the difference between the EV for either decision. It highlights which factors are most influential:

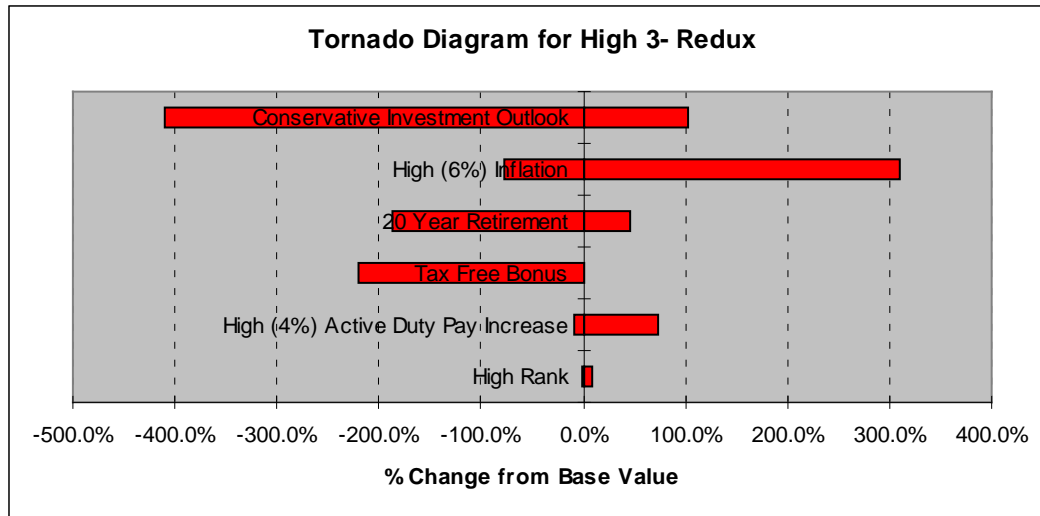


Figure 40: Officer Tornado Diagram for Decision Basis

The two most influential uncertainties are the investment outlook and the inflation rate. The diagram also highlights the fact that changing the investment outlook to moderate will result in the greatest change in favor of the Redux plan, while increasing the inflation rate results in the greatest change for the High 3. The least influential to his decision is Maj Wright's retirement rank.

Summary

The scenarios explained above directly relate back to the real-world decision faced by all Airmen approaching their 15 year service point. By using the model and assessing preference probabilities, more clarity is brought to the decision by showing the expected value of either decision. The sensitivity analysis provides more insight into the decision. By performing the sensitivity analysis on the given examples, the analyst can provide a more detailed look at each of the uncertainties faced by the service member. By understanding which factors have the greatest influence on the decision, more focus and

attention can be centered on the areas. Rather than an arbitrary calculator providing final numbers, the model can provide detailed insight into the decision.

V. Findings / Conclusion

Although the example scenarios include detailed preference probabilities, the sensitivity analysis does allow us to provide some general findings and basic information that can be provided to service members.

Officer Ranks:

1. Across the majority of outcomes, the High 3 decision was strictly dominant.
2. Should not discount the possibility of Redux being the better plan. If there is a 100% probability of tax free investment, many outcomes favor Redux – in fact by just changing Maj Wright's preference in that category, his decision changes to Redux among almost all other outcomes. Additional factors including investment rate of return and length of service provide more incentive.

Enlisted Ranks:

1. The difference between the value of the Redux plan and High 3 are close among most preference probabilities.
2. Investment outlook is a key determinant. While advisable to maintain a more conservative approach, an individual's expected return will have a great impact on the decision.
3. Another key factor is length of service. The more certainty an individual has regarding his retirement timeline, the better decision can be made. In almost

all cases, the longer the service time the more favorable the Redux plan becomes.

General

Perhaps the most important factors to keep in mind are the key assumptions of the model – that an individual will invest all of the Career Service Bonus (if taken) and will not focus on trying to save the difference in pay between the Redux and High 3 if the High 3 is selected. While these are valid assumptions, they are also key to the decision process.

Conclusion

The power of the model is in its simplicity. Although not an advanced problem which requires high-powered math, the model provides a distinct advantage over others currently available. This is a tool usable by EVERY service member who reaches the 15 year point. It is something that is extremely valuable to a vast majority of mid-level military members.

Appendix: Blue Dart

Measuring Risk In Mobility Airdrop

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Word Count: 611

“Airdrops are critical to sustaining ground forces at austere locations where other means of re-supply aren’t feasible.” So says Air Force Colonel David Almand, director of the Air Mobility Division at the CENTCOM CAOC. The amount of cargo delivered via airdrop has grown from 3.5 million pounds in 2006 to over 40 million pounds in 2010, according to AMC Public Affairs. Unfortunately, risk assessment of the potential collateral damage caused by off-target drops has not kept pace with this ever-expanding mission. Decision makers at all levels demand and deserve better than they are getting. A more advanced methodology is proposed which will help bring clarity to the decision making process.

Currently, planning for risk assessment relies on rectangular shapes to categorize areas of probability for missed drops. These categories are the likelihood that the airdrop will land within a particular zone with 50 to 90 percent probability. It then measures the amount of space covered by “Protected Objects” within each zone. Based on the amount space of the protected objects in each zone, the planners determine a level of risk from 1 to 5 (increasing number means increasing risk). These risk levels correspond to the risk levels used by the joint planners for collateral damage estimates from explosives. While seemingly sound from a doctrine standpoint, there are some key problems with the current methodology.

The current methodology does not provide an actual percent chance that a protected object will be struck. Planners can advise the decision maker that according to their calculations, they are at risk level 3, for example. But risk level 3 does not necessarily mean that there is an xx% probability of an airdrop damaging a protected object, or even a range of probabilities. In fact, if the new methodology is applied, it can be shown that there are instances when an airdrop assessed as risk level 2 actually has a higher probability of damaging a protected object than a risk level 3 drop. The main reason that the current methodology allows for such a flaw is that it does not make enough of a consideration for the direction of travel of the aircraft. If a protected object is outside the 90% box, but directly along the direction of travel, it would receive the same score or risk level as a protected object outside the box but well left or right of the direction of travel. By comparing the historical data of both possibilities it can be shown that the protected object along the flight path has a much higher probability of collateral damage. The planners themselves agree that the current method must be improved.

The proposed methodology is based on a statistical analysis of current airdrop data. By applying the data to the closest fit bivariate-normal distribution, it is possible to get a more accurate assessment of the probability of collateral damage. Instead of relying on the series of boxes to distinguish collateral objects, the probability of damage can be assessed directly by applying the model distribution to a given set of inputs including altitude, airspeed, and, importantly, direction of travel. Decision makers will know the assessed probability of damage before approving a particular mission. The concept can be expanded to incorporate joint doctrine, so that each risk level will have an associated probability range of collateral damage.

Airdrop capability is an ever-expanding mission essential to OEF and future possible conflicts and contingencies. Our decision makers deserve a product that provides clarity to the associated risk decision. By implementing the proposed analytical methodology, this clarity can be achieved.

Aaron Larose is a Major in the United States Air Force and a student at the Air Force Institute of Technology studying Operations Analysis.

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Vita

Major Aaron Larose is a proud graduate of San Dieguito High School in Encinitas, California. He was commissioned in 1997 from the United States Air Force Academy with a Bachelor of Science in Space Operations. He was selected for pilot training and after earning his pilot wings he remained at Laughlin AFB, Texas, to be an instructor pilot in the T-37.

Major Larose has had several flying assignments and has accumulated over 3,300 flying hours in T-37, KC-135, and C-17. Additionally, he was selected to be an intern at Air Mobility Command and where he worked at the Tanker Airlift Control Center and Headquarters Air Mobility Command A5/8. He has received numerous awards and honors including Distinguished Graduate of KC-135 initial qualification training, Company and Field Grade Officer of the Year awards, and one of six 2005 Airlift/Tanker Association Young Leader Award Winners. He is currently a student in the Intermediate Developmental Education program at the Air Force Institute of Technology.

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| 1. REPORT DATE (DD-MM-YYYY) | | 2. REPORT TYPE | | 3. DATES COVERED (From - To) | |
| 10-06-2011 | | Graduate Research Project | | May 2010 - June 2011 | |
| 4. TITLE AND SUBTITLE Utilization of Decision Analysis for Service Member Retirement Options | | | | 5a. CONTRACT NUMBER | |
| | | | | 5b. GRANT NUMBER | |
| | | | | 5c. PROGRAM ELEMENT NUMBER | |
| 6. AUTHOR(S) Larose, Aaron, J., Major, USAF | | | | 5d. PROJECT NUMBER | |
| | | | | 5e. TASK NUMBER | |
| | | | | 5f. WORK UNIT NUMBER | |
| 7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(S) Air Force Institute of Technology Graduate School of Engineering and Management (AFIT/EN) 2950 Hobson Street, Building 642 WPAFB OH 45433-7765 | | | | 8. PERFORMING ORGANIZATION REPORT NUMBER AFIT-IOA-ENS-11-02 | |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Intentionally Left Blank | | | | 10. SPONSOR/MONITOR'S ACRONYM(S) | |
| | | | | 11. SPONSOR/MONITOR'S REPORT NUMBER(S) | |
| 12. DISTRIBUTION/AVAILABILITY STATEMENT APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED. | | | | | |
| 13. SUPPLEMENTARY NOTES | | | | | |
| 14. ABSTRACT The Military Retirement Reform Act of 1986 and subsequent repeal in the FY2000 Military Defense Authorization Act resulted in a decision problem for all military members considering retirement. The proper choice between the accepting the \$30,000 Career Service Bonus and Redux retirement pay versus the traditional "High-3" retirement pay must be made by all members approaching 15 years of service. Unfortunately there is very little guidance available for this decision; what little there is can be misleading. The purpose of the model is to utilize decision analysis tools to help bring clarity to the decision problem and allow service members to make their decision based on their preference probabilities and resulting expected values of either decision. The model provides a comprehensive approach to the decision and results in a product that can be used by every service member approaching retirement. | | | | | |
| 15. SUBJECT TERMS Decision Analysis, Preference Probability, Capital Recovery Formula, Expected Value, Sensitivity Analysis | | | | | |
| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 18. NUMBER OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
| a. REPORT | b. ABSTRACT | c. THIS PAGE | | | Dr. Jeffery D. Weir, Civ, USAF (ENS) |
| U | U | U | UU | 78 | 19b. TELEPHONE NUMBER (Include area code) (937) 255-3636, ext 4523; e-mail: jeffery.weir@afit.edu |

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